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Sky and TELESCOPE

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The Editors Note . . .

AN EVENT to which societies of amateur astronomers and many individual amateurs and professionals have been looking forward for some years is now taking place. In process of being formed is the long-awaited Amateur Astronomers League.

Work begun at the first three national conventions of amateur astronomers in 1939, 1940, and 1941, was resumed at Cranbrook this summer. Principal changes in the old AALA by-laws were provision for membership-at-large by individuals and for activity sections to carry on amateur observations and research of value to professionals, and modifications in the dues. The new by-laws comprise all the fundamental principles and ideas of the earlier ones, plus new and invigorating incorporations by the Cranbrook convention. They include the main features of national organization proposed by a committee appointed within the American Association of Variable Star Observers.

Backbone of the operating structure of the AAL will be the member societies. As soon as 10 bona fide organizations have ratified the by-laws, the league will commence operation and establish dues and procedures whereby individuals may become members-at-large. As the letter being sent out with the by-laws states, the time for changes or reservations has passed. The by-laws as adopted at Cranbrook represent years of careful planning and the consensus of many divergent opinions. As soon as the league is formed, amendments will become possible in accordance with the terms of the by-laws themselves.

The final preparation of the by-laws for distribution has been carried out by James B. Rothschild with the clerical assistance of several members of the Junior Astronomy Club, New York City, of which group he is adviser. If your group does not receive a copy of the by-laws by early November, communicate with Mr. Rothschild at P. O. Box 281, Wharton, New Jersey. Ratification advices should also be addressed to him.

The closing words in the letter of transmittal signed by the Committee on Permanent Organization are: "The potential benefits of an Amateur Astronomers League have been a topic of discussion for all too many years. The reality is now within our grasp. Success depends on the co-operation of all."

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Whole Number 61

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COVER: Four of the naked-eye planets as viewed telescopically, from photographs taken at the Lowell Observatory. This is a portion of a plate used in **The Telescope**, Sept.-Oct., 1940, when it was the cover of an issue containing a report on Mars as observed in the Southern Hemisphere by E. C. Slipher in 1939. For an article on the planets in general, see page 12 of this issue.

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BACK COVER: The double cluster in Perseus, h and Chi Persei, photographed with the 36-inch Crossley reflector of the Lick Observatory, and comprising Plate VI of the Lick Album of Celestial Photographs. The exposure time was two hours, on October 22, 1939; aperture reduced to 24 inches. West is at the top of the picture. Lick Observatory photograph.

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STELLAR ROTATION

By Otto Struve, *Yerkes and McDonald Observatories*

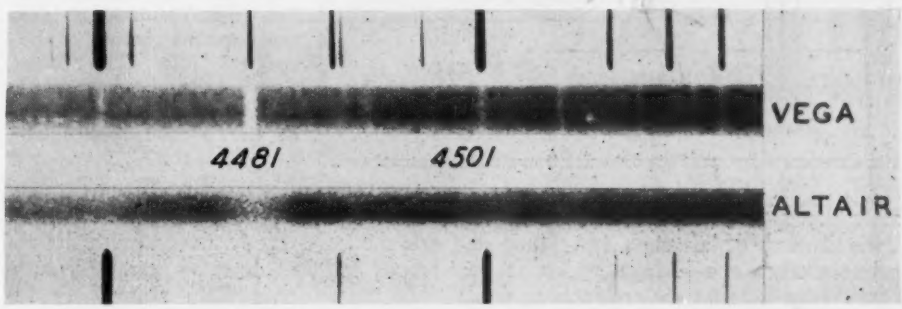
MY FIRST TASK upon arrival at the Yerkes Observatory 25 years ago was to determine the radial velocities of several hundred helium and hydrogen stars* by measuring their Doppler displacements. I vividly recall the feeling of frustration which I experienced when I found that more than half of the stars on Professor Frost's program had such broad and ill-defined absorption lines that accurate settings with the wire of the microscope were difficult or even impossible. It is true that these diffuse lines agreed in position and pattern with the laboratory lines of such common substances as iron, magnesium, calcium, and so forth, so that there could be no doubt about their identifications. But whereas in the laboratory, under low or moderate pressure, the spectral lines are always sharp and narrow, in the stars these same lines may be either narrow, as in Vega, or broad, as in Altair. There is no conspicuous physical difference between these two stars: their temperatures, luminosities, diameters, and masses are roughly the same. Yet, when photographed with a spectrograph of moderate power, their spectra are strikingly different.

To an observer of radial velocities this phenomenon must have appeared as a threat: how can we be certain that the processes which tend to broaden the stellar absorption lines work in a symmetrical manner? Would a setting made upon the geometrical middle of a line, whose edges correspond to radial velocities of, perhaps, +310 and −290 kilometers per second, actually represent the motion in the line of sight of the star as a whole, which may be as small as 10 kilometers per second? Without a knowledge of the broadening mechanism, we could quite easily imagine processes at work whose effect would have been to vitiate the measured velocities. My first interest in the problem of diffuse absorption lines arose from a desire to clarify this question.

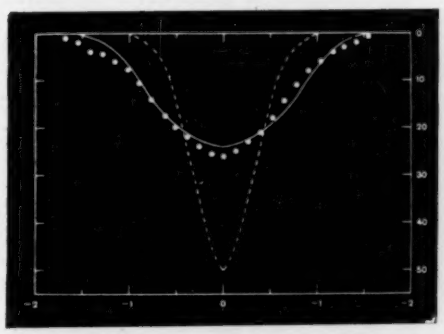
Several astronomers had already suggested that the broadening of the lines could be caused by the rotation of the stars around their axes. But the evidence was very confusing, and the opinions were divided. The prevailing view was to doubt the possibility of equatorial velocities of rotation which exceeded by a factor of 100 the velocity of rotation of the sun.

In an eclipsing variable, during the partial phases, the eclipsing component gradually obscures and then reveals the eclipsed component; just before totality sets in and immediately after it only the opposite limbs of the eclipsed component remain visible. By observing the spectrum at these two times, we should be able to determine the radial velocities of the opposite limbs directly, and then derive the velocity of rotation. This procedure was first indicated by F. Schlesinger, at Allegheny Observatory; but, by an unfortunate coincidence, the two eclipsing binaries investigated by him have relatively small rotational velocities, so that the question of the diffuse lines remained unanswered. Many years later, E. Rossiter and Dean B. McLaughlin independently applied this method to the Michigan observations of Beta Lyrae and Algol, respectively, and established beyond doubt the existence of large rotational velocities in close binaries.

The recognition that rotation accounts for the diffuse lines of *single* stars came gradually. For example, if we determine the velocity of rotation of Algol from the diffuseness of its lines when the star's light is at maximum, we find exactly the same value as that determined from observations of the eclipsing effect. And furthermore, the shape (or contour) of the absorption lines of Algol, outside of eclipse, is precisely the same as that of many single stars, so that there is no reason to doubt that the broadening mechanism is the same. C. T. Elvey has aptly described these lines as "dish-shaped."



Comparison of the spectra of Vega and Altair shows the widening of the lines in the latter star, due to its rapid rotation. The effect is particularly observable in the 4481 line. Negative print from Yerkes Observatory photograph.



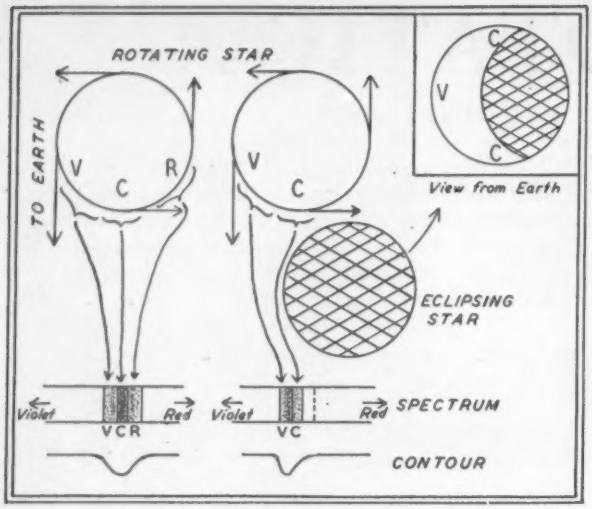
The ionized magnesium line 4481 when Algol is out of eclipse. Abscissas are angstroms and ordinates are percentages of absorption. The observations are shown by the dots. The broken curve represents the assumed contour of the line for a non-rotating star, and the continuous curve is the computed contour for a rotational velocity of one angstrom or 67 kilometers per second. The value adopted from the observed curve is 60 kilometers per second.

An interesting early confirmation of these ideas was obtained by G. Shajn, the present director of the Crimean Astrophysical Observatory in Russia. He photographed the spectrum of Jupiter with the 40-inch reflector at Simeis, and permitted the entire disk of the planet to trail uniformly over the slit of the spectrograph. The spectral lines were appreciably broadened, and since the rotation of Jupiter is known, Shajn was able to verify that the theory gave correct results. The results of Shajn's work, together with my own, were published in 1929 in a joint paper in the *Monthly Notices.*

Since then, he and I, and many others, have worked on the problem of stellar rotation, and the principal results are fairly well known. There are, however, a number of unsolved riddles, and to some of these I should like to devote a few paragraphs.

What is the spectrum of a rapidly rotating star like, when it is observed from the direction of the poles? Among the many stars whose real equatorial velocities of rotation are several hundred kilometers per second, there must be some which are oriented in such a way that we see them from the direction of their axes. The lines would then be narrow and we might find it difficult to distinguish such stars from others whose real rotations are slow. Some time ago I called attention to the fact that in the Pleiades the bright *B*-type

*Stars of spectral classes **B** and **A** are notable, respectively, for the lines of helium and hydrogen in their spectra.



Schematic diagram showing (left) the simple theory of how a star's rotation about an axis approximately perpendicular to the line of sight to the earth widens its spectral lines. The portions V, C, and R of the line come from the corresponding areas of the hemisphere of the star we see. If the star is an eclipsing binary, the eclipsing star may cut off a portion of the line (right) and change the position and contour of the spectral line. The inset shows the "appearance" from the earth at the phase of the eclipse here illustrated.

stars have large rotational velocities. This is true of all such stars in that group except one—Maya. Can it be that Maya is what we are looking for? Its spectrum is not quite normal, although the lines are narrow. But I am unable to find a criterion that would remove the doubt.

A better approach is to consider those helium stars whose spectra possess bright lines of hydrogen (the *Be* stars) in addition to the usual absorption lines. By a somewhat involved, though fairly convincing process of reasoning we have come to the conclusion that the bright lines are produced by rings of nebulous matter which spin around the rapidly rotating helium stars. The rings are presumably formed through the escape of atoms at the stars' equators, because of rotational breakup. Therefore, *the existence of bright lines proves that the rotation is rapid.* If the bright lines, and hence also the absorption lines, are narrow, the axis of rotation is in the line of sight. W. W. Morgan has called attention to the fact that in the most conspicuous objects of this kind the hydrogen absorption lines show the effects of pressure to an exceptional degree. This might mean that the surface gravity at the poles is much greater than at the equator, where it is reduced by centrifugal acceleration. But there are no quantitative measures of the effect and no predictions from the theory of the Stark effect. It is possible that in addition to the phenomenon suggested by Morgan other, and as yet unknown, factors are at work.

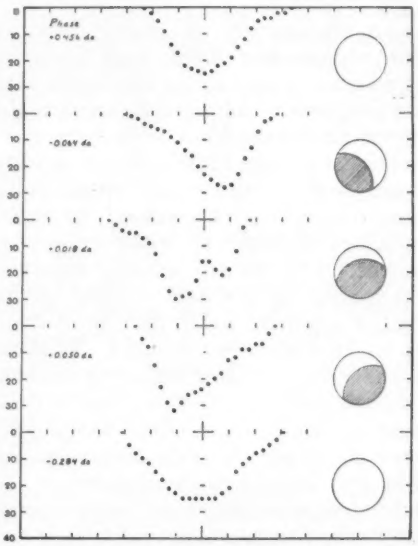
About two years ago F. J. Neubauer, of Lick Observatory, and I observed the eclipsing binary RZ Scuti. During the partial phases the Schlesinger-Rossiter-McLaughlin disturbance in the radial velocities is very prominent. But when we examined our measures of the helium and the hydrogen lines separately, we found that the rotational velocity of the same stellar limb as measured in helium is about twice as large as that measured in hydrogen. The conclusion is inevitable that the star has no sharp edge—we never actually see the edge—but the gases are stratified, with helium below and hydrogen on top. Presumably the inner, helium atmosphere rotates with the star, as the atmosphere of the earth rotates with the latter. But the upper, hydrogen strata fail to keep up with this rapid rotation, and fall behind. This is somewhat like the conception held by some ancient astronomers who denied the axial rotation of the earth because of the "wind" that would be produced by the stationary air.

What happens to an atmosphere when it no longer moves as a single body with the star itself? The limiting case of free atoms traveling through space like tiny satellites is obvious enough. But little is known about the motions of a gas that is intermediate in character. One also wonders what sort of tides will be generated in this mass of gas by the other stellar component of RZ Scuti. Incidentally, the spectrum of U Cephei shows the same effect. We are reminded here of the phenomenon of unsharp stellar edges discussed by the Gaposchkins.

Stratification of gases with the outer layers rotating more slowly than the inner is not a common phenomenon. If it were, we should probably not have discovered stellar rotation in the first place, because that discovery rested primarily upon the fact that in all normal stars all lines of all elements give the same effect of broadening, subject only to the famous Doppler relation that change of wave length is proportional to the wave length. But stratification is conspicuous in several single rapidly rotating stars, as well as in such enigmatic objects as Zeta Tauri and Phi Persei, concerning the nature of which we know very little. In these objects the slowly rotating layers conspicuously display the characteristics of the so-called dilution of radiation effect, which permits us to estimate the radius of the layer. It turns out to be of the order of from one to 10 times the radius of the star itself—making quite a little diffuse halo around it.

These haloes are undoubtedly related to the rings of the bright-line stars. Such rings have also been observed in close double stars, where the opposite protruding limbs of the rings are sometimes eclipsed by the secondary stellar components. The rings are completely detached from the stars, and revolve around the latter in a manner similar to that of the rings of Saturn. The velocities of rotation of the rings as measured by the widths of the bright lines are often very large. In binaries the rotations of the associated stars are not especially large, but for single stars the rotational velocities are always larger than for the rings. This difference must have a cosmogonical cause. Probably the rings of single stars can be brought into being only by rotational breakup with a continuous outflow of gas at the equator, while in close binaries the rings may have been formed before fission permitted each stellar component to settle down with a rotational velocity smaller than that required for breakup. This, however, is all very vague and unsatisfactory. Are the two classical types of breakup really occurring in nature and among stars of roughly similar physical characteristics?

Another question of cosmogonical interest arises when we compare the rotational velocities of the components of close double stars. All systems thus



The effect of rotation as observed in the line 4481 of ionized magnesium in the spectrum of Algol, by Struve and Elvey. The top and bottom contours are before and after primary eclipse. The middle contour is near mid-eclipse, and the indicated splitting of the line is believed to be accidental here, as it is not confirmed on later spectra. The second and fourth contours show the Doppler shift when the light comes principally from that part of the eclipsed star which is approaching or receding from us. Also, note the deepening and asymmetry of the line, giving ample evidence of the rotation effect. Chart from "Monthly Notices."

far observed have rotations in the same sense, namely in that in which the orbital motion takes place. But in some systems, for example in U Cephei, the small, hot, and massive component rotates very rapidly, while the large, cool, and less massive component rotates slowly, perhaps in synchronism with the orbital motion. We have a system resembling that of the earth and the moon. H. N. Russell has suggested that the absence of synchronism in the stars' rotations may be an effect of evolution subsequent to the fission of the binary, an evolution which has proceeded with unequal speeds in the two components. Are there any systems in which the rotations are opposite in sense to the orbital motion, or in which at least one component rotates with a longer period than it revolves? We do not know. Some years ago Z. Kopal computed for Algol, by assuming synchronism, a much larger rotational velocity than had been observed. But the evidence is not conclusive.

Systems without synchronism, like U Cephei, are probably not rare. But they seem to be restricted to those close binaries in which the components differ greatly in physical characteristics. When the components are similar stars, as they are in the majority of ordinary double-lined spectroscopic binaries, synchronism seems to be the rule. It is fortunate that this is so. Much early work on stellar rotation rested on the assumption that synchronism was probable in close pairs, and several studies have been made to find how long, on the average, the period of a binary must be for synchronism to break down. This period, by the way, is much longer than that of U Cephei and other, similar systems. The idea of evolution would fit in nicely with the observations: if the components are physically alike, evolution will presumably change them in the same manner and at the same rate.

We are approaching the toughest question of all: How have the stellar rotations originated? Internal evolution alone, such as contraction, is not sufficient. Otherwise we should expect to find similar rotations for similar stars. The problem is one which reminds us of the related question of the origin of the translational velocities of the stars; the solution of both must be sought in terms of the dynamical properties of the stellar system. Collisions between stars, and between stars and nebulae, may have produced the peculiar distribution which we now observe.

There is a very remarkable relation between the physical characteristics of stars and their average rotations. Among the *O*, *B*, *A*, and early *F* stars we find some that rotate rapidly and some that rotate slowly, but all single stars of classes *F*5 and later have relatively slow rotations. Among the late-type stars only very close binaries, such as W Ursae Majoris, have rapid rotations. The transition at about *F*5 is quite sudden. Why is it that the mechanism of exchange of energy which we postulated in the preceding paragraph leaves the late-type stars with small rotations? Can it be that a large fraction of those late-type stars which would normally possess rapid rotations have, by some as yet unknown process, produced planetary systems and in this manner relieved themselves of a large fraction of their angular momenta? After all, the sun is also a late-type star; and computation shows that if the planets were combined with the sun the velocity of rotation of the latter would be much more rapid than it is at present. It is only fair that I should warn the reader to accept this speculation with reserve. It tells us nothing about the origin of the solar system. It is like a fleeting glance of a cool spring in the heat of the desert. Perhaps it is only a mirage.

Giacobinid Meteors Arrive on Time

THE INFORMATION on Comet Giacobini-Zinner included in the News Note on page 10 of **Sky and Telescope** for August, where Dr. L. E. Cunningham predicted that the earth would cross the orbital plane of the comet at 3^h.0 universal time, or at 10:00 p.m. EST, October 9th, was revised by him late in September, to change this time to about 10:36 p.m. That the meteors kept their appointment with the earth within ten minutes is shown by the following telegram from Dr. Alfred H. Joy, of Mount Wilson Observatory, to Harvard on October 10th:

METEORS SPECTACULAR FOR 3 HOURS MAXIMUM AT 7:45 PACIFIC STANDARD TIME. ESTIMATED MAXIMUM RATE FOR PASADENA SINGLE OBSERVER 1 PER SECOND OVER 5 MINUTES INTERVAL.

Later, G. B. Blair, of the University of Nevada at Reno, wired that the display was spectacular in that region. A letter was received from Dr. L. L. Rice, of Mayland, Tenn., dated October 9th:

"I have just come indoors after watching the brilliant meteor display. It is now 10:15 CST, and the peak seems to have passed. At 8:30 the sky was heavily overcast, but by 9:15 the clouds had lifted and the cosmic fireworks began in earnest. Three of us tried to keep count, but after tallying 500 ceased enumeration. The radiant was as advertised. There was no quarter of the heavens that was untouched by the fireworks. As nearly as we could determine the peak was reached about 9:45."

The American Broadcasting Company, activated by its Boston station, WCOP, planned a nationwide hookup and two days ahead of time chose the period from 10:30 to 10:45 EST. When broadcast time arrived, Mount Wilson Observatory could not be brought in, Cambridge was clouded out, but at Chicago Dr. O. J. Lee, of Dearborn Observatory, participated in the broadcast. He sent the following report at our request (CST times).

"I arrived on the northwest roof of the Merchandise Mart, about 200 feet above the street in downtown Chicago, at about 8:30 in the evening. Meteors were flashing out every few seconds although the sky was fully 8/10 overcast with what the weather bureau told us were altocumulus clouds at 14,000 feet. Meteor counting was going on by the half dozen studio people then observing. The group grew to 25 or more as the out-loud counting went on, until nearly 10 o'clock when heavy clouds stopped the show.

"As we saw them, the brightest meteors outshone Venus at her best, showed red, orange, green, and could be followed even when their paths led behind wisps of clouds. Our counts for 5- to 10-minute periods averaged 5 to 7 meteors per minute. Had the sky been clear and moonless, the display might easily have been 'out of this world.'"

From Cleveland, Dr. J. J. Nassau, of the Warner and Swasey Observatory, reports that it was partly cloudy, although 20 miles from the observatory the sky was clear. Attempts to obtain spectra with the objective prism failed since at maximum the sky was definitely overcast. The best report on counts of meteors came from James L. Russell, of the Cleveland Astronomical Society.

"Three observers covered the sky. We began observing meteors at 6:45 p.m. EST, and the maximum was at 10:45 p.m. Many of them were of the 1st magnitude with short trails. A number were seen to burst; any number left long trains. At least three did not move in a straight line. One showed a reversal in its motion. Many were blue, and later in the evening many were red."

Except for Dr. Jack Pierce and assistants from Harvard's Cruft Laboratory, observers at the Oak Ridge station of Harvard Observatory were practically completely clouded out, and those at Cambridge fared little better. Dr. Pierce's success was accounted for by his use of radar-type equipment to get as high as 14 squeals per minute (a squeal indicates registration of a single meteor), with an average of about 12 meteors per minute for two hours.

Press accounts described similar observations elsewhere. During the height of the shower, the "bumps" in radio reception caused by the meteors blended into a series of flutters. These were observed by radio amateurs in many parts of the country.

At Portland, Me., Herbert Harris and his neighbors were more fortunate than most amateurs along the eastern seaboard, where the coastal storm clouded out a wide area.

"From 10:30 to 11:30 p.m. well over 100 meteors were observed. The moon was very hazy and had a good ring around it. I saw about seven beauties with long, bright trains. Fifty per cent were of the 1st magnitude—the brightest was about

(Continued on page 20)

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 75th meeting of the American Astronomical Society. Complete abstracts will appear in the Astronomical Journal.

The Galactic Bulge

THE APPARENT POSITION of the center of our galaxy in the direction of the constellation of Sagittarius has been known for a quarter of a century, but a bright nucleus or clustering of stars about the center as in other galaxies has never been observed, presumably because of interstellar dust clouds. The use of infrared light should undoubtedly give increased penetration through this celestial haze just as a color screen and red-sensitive plates improve the photography of distant landscapes through the earth's atmosphere.

During the summers of 1945 and 1946, Drs. Joel Stebbins and A. E. Whitford, Mount Wilson and Washburn observatories, made a search in infrared light for a possible bulge or nucleus at the center of the galaxy. They used the 60-inch reflector at Mount Wilson, with a photocell and filter glass giving effective sensitivity near 10,300 angstroms, this being in the deep infrared well beyond the limit of the human eye. The telescope was kept stationary and the diurnal motion swept the sky across a focal diaphragm for intervals of 15 or 20 minutes of time. With readings of sky brightness taken every half minute, any object requiring 40 seconds to cross the field would be measured at least once.

Similar sweeps through red or violet filters served to identify foreground stars and star clouds by their colors; any feature near the actual center would surely be much reddened. In the first year the sweeps covered all of a strip two degrees wide along the galactic equator from galactic longitude 325° to 330°, while in the second year partial coverage was obtained over 10 degrees of longitude and five degrees or more of latitude.

A persistent bulge was found running near and parallel to the galactic equator, its form roughly outlined by an elliptical figure some eight degrees long and 3½ degrees wide, with its center at longitude 326½°. The increase of brightness from the edge to the middle of this figure amounts in the infrared to magnitude 19.0 per square second of arc, referred to an *A*0 star in the zenith. From the gradient in brightness between infrared at 10,300 angstroms and red at 7190 angstroms, it is estimated that the apparent photographic brightness of the bulge would be magnitude 24.5 per square second, or 1/10 the brightness of the darkest patch of blank sky in the neighborhood.

Although the actual nucleus has not been found, the reasons for believing that the central region has been outlined are its position, its form, and above all its extreme redness, which indicates that less than 1/1,000 of the ordinary blue photographic light gets through the obscuring interstellar dust.

Work on Clusters

A GLOBULAR CLUSTER and a galactic cluster were studied by Dr. Helen Sawyer Hogg, of David Dunlap Observatory, and Dr. Philip S. Riggs, of Crane Observatory (Topeka, Kan.), respectively. The latter attached low weight to the results of his work on the colors of early-type stars in NGC 6871, a galactic cluster for which he used plates obtained through color filters with the Crossley reflector of the Lick Observatory. A Ross-type photometer was used to find magnitudes at five effective wave lengths from the ultraviolet to the extreme red.

Dr. Hogg used 62 plates of the very open globular cluster NGC 5053 taken with the 74-inch Dunlap reflector over a nine-year period. All the cluster-type variables were found, in confirmation of work done previously by Dr. W. Baade, to have small ranges of variation, with the periods falling mostly around one third of a day.

The median magnitude of the 10 cluster-type variables is 16.23, with an average deviation of only 0.04 magnitude. This gives a distance to the cluster of about 17,000 parsecs, in good agreement with results from other investigations. The cluster is noteworthy for its very large distance of about 55,000 light-years above the galactic plane.

This cluster is important as a testing ground for the relation between variable and non-variable stars, since several investigators have pointed out that in globular clusters in general the cluster-type variables lie in a definite region of the color-magnitude diagram for each cluster. Furthermore, most of the stars in this region of the diagram tend to be variable. In the color-magnitude diagram of this cluster, Dr. James Cuffey had found 14 stars not classed as variable which he suspected of being so because they were in this region. Dr. Hogg found only one of them to be variable, while the other 13 did not change their light by an appreciable amount. It appears from this that a star in a globular cluster can have the same color and magnitude as the cluster-type variables and not be a variable star itself.

Washburn Observatory, located on Observatory Hill on the campus of the University of Wisconsin in Madison, where the 75th meeting of the American Astronomical Society was held in September. University of Wisconsin photo.

Nova Studies

EACH INVESTIGATOR of Nova Lacertae 1936 has given a different interpretation of the several absorption systems shown by this star after its outburst. Dr. Dean B. McLaughlin, of the University of Michigan Observatory, has combined Michigan, Lick, and Mount Wilson spectrograms to get a complete day-to-day record of this star for the period in question. His results are self-consistent and show some misinterpretations by earlier workers caused by their use of fragmentary data. He suggests that in cases of this kind a continuous record and a study of all available material by a single investigator is essential.

Metallic A-Stars

ALTHOUGH A-STARS are notable for the intensity of the Balmer series of hydrogen lines in their spectra, they also contain weak lines of ionized metals, such as calcium, magnesium, and iron. Dr. Lawrence H. Aller, of the University of Indiana, has investigated certain stars of this type which show abnormally intense metallic lines, using plates obtained by Dr. Paul W. Merrill with the 100-inch and 60-inch telescopes at Mount Wilson Observatory.

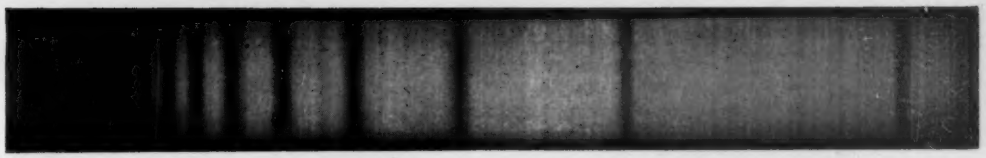
From the hydrogen lines, Dr. Aller estimated the number of atoms of hydrogen (Balmer energy level) above each star's photosphere, and the results compared well with those for such well-behaved *A* stars as Sirius, thereby confirming the *A*-type classification. The number of metallic atoms above the photosphere, however, turned out to be about 10 times greater than normal, that is, the metals to hydrogen ratio was 10 times higher for a metallic *A* star than for a normal one. No attempt was made to differentiate among the various metals involved, as the dispersion of the plates was too low. High-dispersion spectra are particularly desirable for a continuation of the work. This is especially important since most of the stars on Dr. Aller's list appear to be possible spectrum variables — certain lines of the metals vary in a periodic way which is not understood by astronomers at present.

This last problem was the subject of a paper by Dr. Armin J. Deutsch, of Yerkes Observatory, who has compiled a catalogue of spectrum variables giving the gross spectroscopic characteristics of all such stars now known. He showed that some of the spectrum variables are giant stars, and that all may be. He also pointed out that the spectrum variables, and the peculiar (metallic) *A* stars in general, are appreciably bluer than normal stars of the same spectral type.

The Double Cluster

A PLOT of the known non-supergiant emission-line stars in the region of the double cluster in Perseus (see back cover this month) shows that there is a much more pronounced grouping of these objects about the cluster Chi Persei than about the other half of the double system. This difference is unexpected, inasmuch as both clusters appear to be of similar constitution. When spectral class is plotted against magnitude, the curve has the same form in each case, but now it appears that there are more *Be* stars (*B*-type stars with bright lines in their spectra) in the Chi Persei region.

This study was made by Dr. W. P. Bidelman, of Yerkes Observatory, who eliminated all supergiants from his study as such stars are thought possibly to have bright lines in their spectra at some time during their existence. The non-supergiant stars may possibly derive their bright lines from a shell of gas thrown off by rapid rotation. Further spectra are necessary to determine finally whether or not this is the case.



The spectrum of a typical A-type star, showing the prominent lines of the Balmer series of hydrogen and the weak lines of the metals.

Meteorites and Space Travel

ASTRONOMERS are being called upon to determine the hazards of travel through space in pressurized rocket ships. Dr. Fred L. Whipple, of Harvard College Observatory, has made computations of the probability that the skin of a space vessel will be punctured by a meteorite, and he proposed a "meteorite bumper" as a means of protection from meteorites.

In his study, Dr. Whipple assumed that the spaceship travels in a part of the solar system where the meteoritic frequencies and velocities approximate those at the earth. He assumed that 4.5×10^7 5th-magnitude meteors strike the earth daily and that the number increases by a factor of 2.51 per magnitude fainter, as proposed by Dr. Fletcher G. Watson; also, after Opik, he considered the total kinetic energy of a telescopic meteor to be 1/0.0006 the energy observed in the wave length region from 4500 to 5700 angstroms.

His final postulate is that the penetrating distance of a meteorite into a solid is equal to (extreme assumption) the length of a right circular cone of 60-degree total apex angle, the volume of which in the solid can be heated and melted by the total kinetic energy of the meteorite.

From these premises, it follows that a spherical space vessel of 12 feet diameter covered with a 1/4-inch steel skin will be penetrated by a meteorite corresponding to an 8th-magnitude or brighter meteor at the rate of once in 50 years. Such a meteorite weighs approximately a milligram. For thinner coverings the probability increases rapidly.

Although the probability of meteor penetration is small, a simple protection can be provided other than by the avoidance of known meteor streams. Considerations of the conservation of momentum and energy show that when a meteorite collides with a sheet of a thickness comparable with the meteorite's diameter, the result is an explosion in which both the meteorite and the corresponding material of the sheet are vaporized and ionized at a very high temperature. Hence, a "meteorite bumper" consisting, perhaps, of a millimeter-thick sheet of metal surrounding the 1/4-inch skin of the spaceship at a distance of an inch would dissipate the penetrating power of a meteorite several times larger than one corresponding to an 8th-magnitude meteor.

The very rare collision that may occur with a large meteorite, one the size of a pea or a walnut, would completely destroy the space vessel. Fortunately, the probability of such an encounter is exceedingly small.

Solar Spectrum Line Intensities

DR. M. MINNAERT, of Utrecht, Holland, temporarily at Yerkes Observatory, described work now going on to compile a catalogue of the intensities of the Fraunhofer lines in the solar spectrum. Just before the war, the Utrecht Observatory published the *Photometric Atlas of the Solar Spectrum,* giving a graphic record of the intensity distribution in all the Fraunhofer lines. The new catalogue, compiled from the atlas, is already complete for the red and infrared regions.

Electronics and Star Diameters

WASHBURN OBSERVATORY has long pioneered in the application of photoelectric devices to astronomy. The photocell has been used by Wisconsin astronomers to replace the eye or the photographic plate at the telescope, thereby enabling very precise measurements of magnitudes and colors to be made. This summer, Dr. A. E. Whitford, employing the 100-inch telescope at Mount Wilson, performed an observational feat which has hitherto been beyond the ability of even the largest telescope.

From a high-speed record of the way a star's light varies as it is occulted by the edge of the moon, Dr. Whitford was able to measure the star's diameter. To the eye, an occulted star appears to go out instantaneously, but to the photoelectric cell, oscilloscope, and moving-film camera there is a waver in intensity about 1/50 of a second before the star goes out. This is because diffraction past the moon's "edge" produces fringes in the same manner that diffraction of the Fresnel type makes fringes in laboratory experiments in optics (see *Sky and Telescope,* No. 46, page 7). The laboratory fringes are a few thousandths of

an inch apart, but in the case of the moon the obstruction is 238,000 miles away and the fringes spread out to about 30 feet apart. Because of the moon's motion they sweep across the telescope at a speed of over 1,000 miles an hour.

As every star must have an apparent angular diameter, no matter how small, it is not quite a point source and the diffraction pattern is not quite as pronounced during the occultation as would otherwise be expected. From the difference between the theoretical pattern for a point source and the observed pattern, Dr. Whitford was able to calculate the apparent diameters of four stars. For Nu Virginis, Kappa Virginis, 44b Ophiuchi, 191 B Ophiuchi, the angular sizes are 0.008, 0.055, 0.002, and 0.001 seconds of arc, respectively. The values for the last two stars served principally as checks on the method. With Dr. Whitford's equipment as used this summer, angular diameters between 0.005 and 0.018 seconds can be measured with a 10-per-cent error. About a dozen stars of this size range are situated along the zodiac where the moon can occult them. The first-quarter moon is used to procure a dark-edge occultation and to enable guiding on the star right up to the moon's limb.

Dr. Whitford has interpreted each star as consisting of two halves, following the theory used in the well-known interferometer measurements by Pease at Mount Wilson in the early '20's. Eventually, for the present observations, the theory of the star as a series of "slices" must be developed. Smaller telescopes can also be used for these observations, on brighter stars and with a narrower wave length region so the light is more nearly monochromatic. The larger the telescope, however, the better the signal-to-noise ratio in the electronic apparatus.

It is important to note that the distance of each star must be known before its actual diameter in miles can be computed. Dr. Whitford's results agree closely with calculated diameters of these stars by other means. This agreement confirms the belief that the moon has no appreciable atmosphere — even 1/10,000 as much air as the earth has would have hopelessly blurred the diffraction fringes.

At Washburn Observatory, Dr. Whitford demonstrated to the meeting the new RCA photomultiplier tube (1P21) in place of previously used photocells. The simplicity and high sensitivity of the tube make it especially suitable for astronomical observations. The original electrons emitted by the photosensitive surface of the tube are amplified by a series of nine electrostatic lenses and secondary emissive surfaces. The final energy output is so great that it may be applied directly to the galvanometer or the oscilloscope registering the magnitude of the star under observation.

Amateur Astronomers

THIS MONTH'S MEETINGS

Chicago: On Tuesday, November 12th, at 8:00 p.m., the Burnham Astronomical Society will meet at the Chicago Academy of Sciences Auditorium. This is the annual meeting, and there will be election of officers. Professor Robert L. Price, of the Joliet Junior College, will speak on "Astronomy and the Physicist."

Cincinnati: Dr. Paul Herget, of Cincinnati Observatory, will be speaker at the meeting of the Cincinnati Astronomical Association on Friday, November 8th, subject to be announced. The meeting is at the observatory, at 8 o'clock.

Cleveland: "Meteors and the Earth's Upper Atmosphere" will be discussed by Dr. Fred L. Whipple, of Harvard College Observatory, at the November 8th meeting of the Cleveland Astronomical Society. The group meets at 8 o'clock at the Warner and Swasey Observatory, East Cleveland.

Detroit: On Sunday, November 10th, at Wayne University at 3:00 p.m., Dr. Otto O. Fisher will show to the Detroit Astronomical Society his collection of Paricutin volcano films in color, to which some important material has just been added. "Highlights of the November Skies" will be presented by L. B. Christensen, and there will be observing with portables later in the evening.

Indianapolis: At the meeting of the Indiana Astronomical Society in November, Emsley W. Johnson will speak on "Lights in the Sky." The meeting is at Odeon Hall on Sunday, November 3rd, at 2:15 p.m.

Kalamazoo: Meeting in the Science Hall at Kalamazoo College, on November 9th, the Kalamazoo Amateur Astronomy Association will hear a talk by Dr. J. Hornbeck on "The Spectroscope in Astronomy."

Madison: Amateur members will speak at the meeting of the Madison Astronomical Society on "Astronomy Before Tycho Brahe." George Mackin, Charlotte Stewart, and Gene Charmley will discuss the Greek period, the Arabian period, and the early European period, respectively. The meeting is on November 13th at the Washburn Observatory, at 8:00 p.m.

New York: "Atomic Power" will be the subject of the discussion by Dr. Robert I. Wolff, College of the City of New York, at the November 6th meeting of the Amateur Astronomers Association. The meeting is at 8 o'clock in the Roosevelt Memorial building, American Museum of Natural History.

On November 22nd at 8:00 p.m., Dr. Charles P. Olivier, of Flower Observatory, will speak on "Comets and Meteors" at the meeting of the Junior Astronomy Club, in the Roosevelt Memorial building.

Philadelphia: At the meeting of the Rittenhouse Astronomical Society on November 8th, Everett C. Yowell will speak on "Pulsating Stars."

Pittsburgh: On Friday, November 8th, Dr. Henry Leighton, of the University of Pittsburgh, will give a talk entitled "Meteorites," at the meeting of the Amateur Astronomers Association. The talk, which begins at 8:00 p.m., will be supplemented by samples of meteorites, and Dr. Leighton will report on the Bradford Woods, Pa., meteorite.

Eleven Years of Classes in Telescope Making

On October 15th, the Optical Division of the New York Amateur Astronomers Association began its 11th year of classes in telescope making. This year the course is more extensive than ever, as it includes lectures on elementary optics and on the design and construction of telescope mountings, in addition to the usual guidance in making a 6-inch reflecting telescope mirror.

Earle B. Brown, editor of Gleanings for A.T.M.s in *Sky and Telescope*, is one of the instructors for these classes. The others are Walter Howland, Richard S. Luce, Alex Singer, and Allyn J. Thompson, author of the series of articles on telescope making published in Volume IV of this magazine.

Classes are now held on three evenings each week, with each student attending once a week for 25 sessions of three hours each. The course is accepted for in-course credit for teachers by the Board of Education of New York City. Further information may be obtained by telephoning ENdicott 2-8500, Extension 509, weekday evenings, or by writing the Optical Division, A. A. A., Hayden Planetarium, 81st Street and Central Park West, New York 24, N.Y.

R.P.I. Open Nights

Open nights have been announced at the Rensselaer Observatory at Rensselaer Polytechnic Institute, to take place on November 7th, December 5th, January 30th, February 27th, and several for the spring of 1947. In addition to an evening lecture, a 12-inch reflector and refractors of six, 5½, and 3½ inches aperture will be available for observing. It is necessary to send a stamped, self-addressed envelope and a request for tickets to the Rensselaer Observatory, R.P.I., Troy, N. Y. In addition to this series for the general public, eight evenings at the observatory have been set aside for the school children of Troy.

ASTRONOMICAL ANECDOTES

TYCHO, THE STAR GAZER (1546-1601)

Commemorating the 400th anniversary of the birth of Tycho Brahe

THEY CALLED HIM TYCHO BRAHE, this noble Dane
Who searched the skies above his native land
And over half of Europe ere he died,
An exile, far from Denmark and his home.
A noble was he born, and in those days
A noble must by neither deed nor word
Do aught but play at law and politics.

At Knudstrup he was born, in days when kings
Of Denmark ruled the lands beyond the bounds
That Denmark knows today. In Scania was
His home, from which, a lad, he sailed across
The Sound to Copenhagen, there to be
A student in the University.
But how could thoughts be chained to rhetoric,
Philosophy and history? Eclipse
Of Sun astronomers foretold had come
Precisely on the hour of very day,
And Tycho's mind was captured by the fact.

At Leipzig, then, his tutor tried to hold
The sixteen-year-old boy to rightful thoughts,
But Tycho watched the sky, and noted once
How Jupiter and Saturn passed, at time
A full month wrong by all authority.
At Leipzig, too, he purchased instruments
Wherewith he learned the arts of measuring,
And knew at once that any tool that man
Has made must have its errors, small or large,
And only care can yield a true result.
Through all his life, the instruments he made
Were fashioned far beyond the common style
Of those who furnished scientific tools,
And in the hands of Tycho plumbed the skies
With zeal and skill that others never knew.
When years had passed, and Tycho was no more,
His pupils gathered from his work the truths
That would not yield to Tycho who was bent
On observations of the wandering stars
We call the planets. Tangled were their ways
By all the rules of ancient theorists;
The tolerance of only highest truth
By Tycho in his measurements must be
Acknowledged as the key unlocking doors
To beauty of geometry's design
Revealed in planetary arabesques
That curl among the stars in tempo of
The Music of the Spheres.

But Tycho's life
Was scarce a third unwound when Wittenberg
And further learning beckoned him. Again
He traveled on to Rostock. There he felt
The steel that slashed his face and ripped
The nose from noble countenance. By some
It's said that it was over love of maid
That Tycho and some unremembered foe
Had fought with blades at dead of night until
The Danish blood was shed to bring an end
That forced poor Tycho evermore to wear
A silver mask to hide disfigurement.
But likelier is it than this that one
Had questioned Tycho's skill at numbering:
To yield to such a charge would scarce befit
The fiery temper of the Danish knight,
Who chose to answer insult in the way
That custom of the day decreed should be
A gentleman's. But mathematical
Or no, the skill at swords of Tycho's foe
Was great enough to cut the Danish nose
Beyond repair, and even unto death
The mask was worn, to hide poor Tycho's scar.

To Basle and to Ingolstadt the Dane
Betook his way and learned at every stay
Full measure of the lore of stars as yet
The foremost scholars of the day could teach.
At Augsburg, then, he met rich citizens,
The brothers Hainzel, who commissioned him
To build for them a quadrant of a size
As yet undreamed. To put upon the rim
A scale of minutes of degrees, the Dane
Assigned a radius but one scant foot
Less than a score — a mighty instrument
Such as the world had never seen before.

At Augsburg, too, the greatest globe of all,
A full five feet from pole to pole, began
To be reality; from time to time
The Dane would add a touch, now here, now there,
To bring the project to an end. And on
This globe, throughout the years, the places true
Of stars were marked as Tycho measured them.

At four-and-twenty years, the wanderer
Returned to Helsingborg; his father died,
And Tycho went to dwell with uncle who
Was brother to his mother; Bille was
His name, and Bille-Brahe in Denmark yet
Is honored name, three centuries and more
Beyond the time when Tycho sought a home
With uncle Steen. There Tycho strove to learn
The rudiments of alchemy, awhile
The stars were suddenly all but forgot.
A many-sided mystic was this Dane,
Whom Nature wooed in all her devious ways.

There came a night when Tycho, walking late,
Saw high above, aglisten in the sky
Of young November, where no star had e'er
Been seen before, a brilliant blazing orb
In Cassiopeia's Chair — a star unknown
From man's remotest days until the night
When Tycho saw its shining splendor flare
As bright as Venus, brilliant even-star.
At age of twenty-six, this miracle
Had come to draw the thoughts of Tycho back
To stars, and all the false beliefs of those
Who were accounted wise in these affairs.

Now in those days the stars regarded were
As signs and portents telling men their fates;
And Tycho sought to read from this strange star
The future of the great of many lands.
In after-years, his pupil Kepler said,
"If naught that star accomplished else, it told
"The advent of a great astronomer."

A year and four months more this star remained
As bright as human eye demands to see:
The nights were spent in measuring its place
Among the other stars called fixed. No shift
Could be discerned, as for the Moon, whose span
From Earth is small enough to let a shift
Appear, when stations two or more are used
To take the measure of its place; the star,
So Tycho said, must lie beyond the Moon.
Yet motion there was none, and so this star
Must lie beyond the planets, even, and
Among the stars, where Aristotle said
Corruption and degree of change unknown
Would ever be. To challenge thus the words
Of ancient scribes was in those days a thing
Not done: authority of great reknown,
Especially from far antiquity,
Was never checked or seldom otherwise
Brought into argument.

But Tycho's rule
Was ever thus: To seek the truth and let
The measurements decide. He knew the star
Must lie among the other stars; that change
Had thus been found where Aristotle said
No change would ever be. He wrote a book,
This Danish Tycho Brahe, to tell of all
His measurements and thoughts upon the star.
But even this came hard to him who deemed
That noble friends would disapprove of such
Display of thoughts that lay beyond the bounds
Of what the knightly practices should be.

His work had some small fruit, for Tycho Brahe,
When he was twenty-eight, and for a year,
At Copenhagen lectured on his stars
At that same University where, young,
His own adventures in the realm of law
And other knightly studies had begun.
Then for another year his wand'ring feet
Again were set on soils of many lands;
To Basle he returned, and there he yearned
To stay and dwell, but restlessness called him
To Venice. Then he came to Regensburg,
Where first he found a written work on stars
Copernicus had penned; another mind
Had tried to pierce the veil of ancient lore
To see as far as truth itself might shine.
This Polish work that Tycho found, he read
With zealous care, and yet he dared to doubt
The theory that taught that Earth revolved,
As other planets, 'round the Sun.

The truth
He spurned, did Tycho Brahe, but only as
His measures, later, failed to show the shift
That should ensue, as Earth was moved from end
To end of yearly path. He worshipped truth,
This Tycho Brahe, but failed to guess the truth
That instruments far mightier than his
Might one day snatch the tiny mote of fact
That his machines could not begin to find.
To bring himself to judge the stars so far
Away as to defy his measurement,
If Earth did move, was quite beyond his heart;
"Why then," said Tycho, "they would lie beyond
"The Saturn planet by a gulf so great
"That so much waste of space would be indeed
"Contrary to the wisdom of the One
"Who made all heav'n and Earth." He dared to judge
What God himself would deem to be the best
Of distributions of the stuff of which
The universe is made. This Tycho Brahe
Was arrogant at times, and adamant
Besides, when his own way he thought the truth.
But this is but a trait that makes us know
That he was yet a man, who towered above
The other men who lived in his own age.

At length the fame of Tycho reached the ear
Of Denmark's king, the second Frederick;
His royal bent was toward the sciences
And all good literary works of men
Of Denmark and of other lands as well.
A score and ten of Tycho's years had passed
When Frederick determined that the stars
And Tycho's work should share the royal purse,
And forthwith dedicated a small isle
To Tycho's purposes. The wizard of
The stars should have to hold unto himself
The isle of Hveen, that lies off Elsinore.
The income from the tenants on this land
Should be for Tycho's use, and purse besides,
To make his labors free from fear of want.
And to ensure that Tycho's instruments
Should be the finest e'er the world had seen,
A structure should be built from royal funds,
To house the mightiest machines that mind
And tools could fabricate. All this had come
To Tycho, who had brought reknown to king
And country by his trafficking with stars,
Contrary to his noble heritage.

The Castle of the Heavens soon took form:
Uraniborg its name, which four-square stood
On Hveen, its faces turned against the points
Of compass, north, south, east and west; the walls
That sheltered it from lands without contained
The gardens and the walks where students swarmed
In years to come. A fitting home it was
For Tycho, noble Dane, who built into
Its bulk, aside from all the tow'rs to house
His instruments, such knightly needs as forge
And dungeon keep, and printing press wherewith
He'd put on paper ink to tell the work

(Continued on page 15)

In Tribute . . .

James H. Jeans

SIR JAMES HOPWOOD JEANS died on September 17th, at the age of 69 years. His death removes one of the last representatives of a great generation of theoretical astronomers, and severs a link with the earlier traditions, for he was a worthy pupil of Sir George Darwin.

Jeans' work was of immense range and versatility, and the recognition that it earned was reflected in honors throughout the English-speaking world. He received honorary degrees from the universities of Oxford, Manchester, Benares, Aberdeen, Johns Hopkins, Saint Andrews, Dublin, and Calcutta. He was knighted in 1928 and received the Order of Merit — a signal honor in Britain — in 1939. President of the Royal Astronomical Society from 1925 to 1927, and of the British Association for the Advancement of Science in 1934, he also filled the distinguished position of secretary of the Royal Society from 1919 to 1929.

Sir James Jeans was a desk astronomer; he worked with observations, but did not make them, and his closest link with an observatory was as a research associate of Mount Wilson from 1923 on. He served as professor of astronomy at the Royal Institution, London, and lectured at Cambridge University. From 1905 to 1909, he lectured at Princeton University in applied mathematics, and he returned to England with an American wife.

The range of Jeans' work can be suggested by the titles of his books, for he was a prolific and brilliant writer, and it is an index of the quality of his work that many of them are still standards on their subjects. At first his interests were concerned with classical applied mathematics, and he gave us *The Dynamical Theory of Gases* (1904) and *Theoretical Mechanics* (1906). The following years saw him turning toward theoretical physics, and he produced his classical *Electricity and Magnetism* (1908), still a standard work, and *Report on Radiation and the Quantum Theory* (1914). During the succeeding years he found his metier as the follower of Sir George Darwin, and embarked on the researches in cosmogony with which his name will always be associated. In 1919 he won the distinguished Adams prize of Cambridge University with *Problems of Cosmogony and Stellar Dynamics*, and this was followed in 1928 by his most significant book, *Astronomy and Cosmogony*. The enquiries, which began with an attempt to trace the development of the solar system by fission, on the lines already outlined by Sir George Darwin, developed into a powerful study of the evolution of stellar and gaseous masses, and led their author to speculate boldly and fruitfully on the development of stars and of spiral nebulae.

On the occasion of the presentation of the Gold Medal of the Royal Astronomical Society to Jeans in recognition of his work on cosmogony, Sir Arthur Eddington (then president of the society) delivered an address which must stand as a classic in exposition of the subject; his closing tribute is memorable:

"... Jeans' contributions to cosmogony are not to be summed up in snappy sentences — that the solar system was formed by tidal disruption, that a spectroscopic binary cannot be formed until a comparatively high density is reached, that star-streaming must be in the transverse direction, and so forth. How these suggestions will stand twenty years from now [1922] we cannot predict. As Jeans has said: 'It has not been part of our task to arrive at a conclusion; the time for arriving at conclusions in cosmogony has not yet come.' There are many who think that conclusions of this kind are a measure of the success of an investigator; but they make a great mistake. He is spinning the threads of a great synthesis; and it would be scarcely human, nor indeed scientific, not to cast curious glances at the pattern that is being formed, of which we can catch elusive glimpses. I will not predict how far the final fabric will be like that which we now seem to see through the eyes of our Medallist; but I will predict that in that fabric there are stout threads of his spinning which will not have to be unpicked."

During the years when Jeans was working on the problems of rotating gaseous masses, he was concerned also with many other astronomical problems. His early interest in the dynamical theory of gases flowered into a study of the dynamics of groups of stars; and he made a vigorous attack on the riddle of stellar constitution, and the problems of intrinsic variable stars. These problems were the themes of theoretical astrophysics in the '20's, and many of them have not been finally solved today. The polemics of the theory of stellar constitution, with Jeans and Eddington as the chief protagonists, are famous in scientific controversy. It is fortunate that the brilliant exposition and repartee of some of these discussions are preserved in print in the pages of *The Observatory*, where the meetings of the Royal Astronomical Society are reported. We shall not listen to their like again.

The '20's and early '30's saw the birth of a deep popular interest in scientific work, and Jeans was not slow to respond to the demand. He was a brilliant writer of English, a gift that won him a place in *The Oxford Book of English Prose* beside the masters of the language. His first popular book, the modest *Eos, or the Wider Aspects of Cosmogony* (1928) was followed by the more pretentious *The Universe Around Us* (1929), *The Mysterious Universe* (1929), *The Stars in Their Courses* (1931), *The New Background of Science* (1933), and *Physics and Philosophy* (1942). These popular books enjoyed an immense vogue, not only for their brilliant descriptions of the universe, but also for their excursions into philosophy and their attempt to formulate a connection between the physical and the spiritual. To the scientific reader, however, they are a disappointment; one feels that the mysterious universe was no mystery to Jeans, and that the philosophical speculations lack the simple sincerity of the writings of Eddington on the same subjects.

During his last years, Jeans made fewer contributions to astronomy; he did not keep in close touch with the changing observational picture of the universe, and his interests turned into other channels. The last of his books dealt with the physics of music.

An epoch has passed with the passing of Sir James Jeans. His was a contribution amazing in breadth and vigor: applied mathematics, theoretical physics, stellar dynamics, theoretical cosmogony, stellar constitution — all these were his province, and all of them he enriched. His personality, too, is not to be forgotten — the robust and impressive figure, the brilliant and compelling speech. His work is a perfect illustration of the application of classical methods to the problems of astronomy; and his contributions will long be classics in their own right.

CECILIA PAYNE-GAPOSCHKIN
Harvard College Observatory

W. Carl Rufus

ON SEPTEMBER 21st, at his summer home at Crooked Lake, Mich., Dr. W. Carl Rufus, retired University of Michigan astronomer and Oriental scholar, died of a heart attack, in his 71st year. This was little more than a year after the tragic death of his wife in a plane crash in June of 1945.

Amateurs who attended the convention at Cranbrook in July well remember the great interest displayed by Dr. Rufus in the convention activities, despite the fact that his physician had advised against his attendance for any protracted period. His loss will be especially felt by the Detroit Astronomical Society, where he frequently lectured. He was always willing to help amateur astronomers, and he en-

joyed writing popular articles on astronomy. His contributions to *Sky and Telescope* were concluded with an article on the northern lights published in the September, 1946, issue.

He received his Ph.D. from the University of Michigan in 1915. In 1917, Dr. Rufus was appointed instructor in astronomy at Michigan, becoming full professor in 1941. He did research in variable stars and spectroscopy, but his principal interest was the history of astronomy, which was an outgrowth of his many years as a teacher and missionary in the Orient. As a member of the university's committee on Barbour scholarships, he counseled a large number of women students from the East.

His early years were spent at insurance and teaching in Michigan secondary schools. In 1905 he became a pastor of Methodist Episcopal churches at Dryden and Owosso. He returned to teaching with a Korean assignment in 1907, and was instructor in mathematics and astronomy at Pyeng Yang College until 1911. Two years later, he taught at Chosen Christian College for four years.

The following excerpts are from a note read at Dr. Rufus' funeral and written by Dr. Edward W. Blakeman, counselor in religious education at the University of Michigan. His office and that of Dr. Rufus adjoined each other in Angell Hall:

"For those who lived close to W. Carl Rufus, this man was more artist than scientist. When his poems are edited we shall see his soul, for he wrote about birds and squirrels as well as of the mighty orbits, the planets, and the millions of miles in space.

"Just when he learned his mathematics few of us have been able to discover. In his early years, when most scholars in the making would have devoted continuous hours to Euclid and the science of numbers, he was completely absorbed in earning a living at insurance and secondary education. Likewise, his first professional years, instead of being devoted to physics and astronomy, were given over to an enthusiasm initiated by his bride. This made him a missionary. It was in Korea, with a tiny telescope, that he accomplished high mathematics and the history of astronomy among the scholars of the Far East.

" . . . this quiet, soft-spoken, humorous gentleman was both a child of his era and a person unique in human relations."

C.A.F.

The INDEX for Volume V

is now in preparation. Its style is similar to previous indexes, including title page; author, title, subject, and topic references. Send 35 cents in stamps or coin, or include it with your subscription renewal check or money order. Your copy of the index will be mailed as soon as it is printed.

SKY PUBLISHING CORPORATION

NEWS NOTES

By Dorrit Hoffleit

THE ICAROSCOPE

The icaroscope is a new optical device for observing objects in the sky near and in front of the sun, developed as a result of wartime research. It was described at the October meeting of the Optical Society of America in New York by Dr. Brian O'Brien, of the Institute of Optics, University of Rochester. The principle of phosphorescence is employed, using special kinds of phosphors with strong afterglow properties which are not much greater, however, for exposure to the sun itself than for exposure to the sky around the sun. This achieves a reduction in the intensity of the solar image sufficient to permit observation of the sun and surrounding sky simultaneously.

The afterglow image does not persist very long, nor is it desirable that it do so if scanning of the sun and sky is to take place. The icaroscope is fitted with a rotating shutter which regularly interrupts the sunlight striking the screen which is coated with the phosphor. Each time the phosphor is exposed, it is energized to emit the afterglow image. Another similarly rotating disk shields the screen from the observer while the sun is shining on it, but allows him to observe the screen between exposures, when the afterglow image is visible. The contrast between the sun and its surroundings is reduced to a small fraction of its original value. At a rate of 90 exposures a second, persistence of vision obscures the fact that the image is not continuous.

The entire icaroscope, including optical parts for viewing the image, is small enough to be carried almost as easily as a pair of binoculars.

A use for the icaroscope which was probably not foreseen during its development was the observation of the initial flash of the above-water explosion of the atomic bomb at Bikini this summer. It made possible direct visual observation of that extremely intense light source.

AN IRISH-AMERICAN TELESCOPE

A new type of telescope will be erected at Harvard Observatory's station in South Africa through international co-operation among the governments of Eire and Northern Ireland, and Harvard University. Announcement of the new plans was made at the Madison meeting of the American Astronomical Society by Dr. Harlow Shapley.

The telescope is to be of the Baker-Schmidt type, designed by Dr. James G. Baker (see page 107, *Telescopes and Accessories*), and employing a second mirror to produce a flat field and shorter tube length than the conventional Schmidt. The new instrument will be mounted in place of the now outmoded Bruce refractor. The correcting plate will be about 32 inches, the primary mirror approximately 36 inches, and the secondary nearly 17 inches in diameter. The effective focal length will be nearly 120 inches. At the focus, images will be of uniformly high excellence over the 10-inch circular field.

This plan for international co-operation combined with astronomy was first discussed by Dr. Shapley with Prime Minister de Valera when the former was on his way to a meeting of the International Astronomical Union's executive committee in Copenhagen last March. In addition to the observatory of the archbishop of Armagh, Dr. Eric Lindsay, director, it is expected that the presently dormant Dunsink Observatory at Dublin will take part in the program.

NAVAL OBSERVATORY SUPERINTENDENT

Captain Guy Wheeler Clark, U. S. Navy, became superintendent of the U. S. Naval Observatory on September 1, 1946, relieving Captain R. S. Wentworth, who has been retired. Captain Clark graduated from the U. S. Naval Academy in 1917, and was assigned to sea duty during World War I. His various assignments during World War II include command of a destroyer, a transport, and a cruiser; Naval War College, command course, and chief of staff to Commander Amphibious Force 7th Fleet. Prior to his present appointment, Captain Clark served as deputy superintendent for one year.

A NEW THEORY

The spectra of some stars, such as the recurrent nova RS Ophiuchi, are very peculiar in that they indicate both very high and very low stellar temperatures simultaneously. Many years ago Dr. Donald H. Menzel, of Harvard, proposed that such stars might in reality be double, consisting of a large, cool red star and a small, hot blue companion.

At the recent convention in Amsterdam, Holland, commemorating the 50th anniversary of the discovery of the Zeeman effect (the splitting of spectral lines in a magnetic field), Dr. Menzel stated that he no longer subscribes to his older hypothesis. He now proposes that a single star with a small, hot nucleus is surrounded by an extensive atmosphere supported by a combination of radiation pressure, turbulence, and stellar rotation. Such a star would bear some comparison with a planetary nebula, but the large surrounding atmosphere would have transformed much of the high-temperature radiation from the nucleus into red light.

FROM ONE PLA

By Robert R. C

CURIOSITY may have been responsible for the sudden demise of a certain feline, as the old saying goes, but, on the other hand, that same trait in man has opened many secret doors and revealed many facts about the universe that were once entirely hidden from us.

Although earth-bound in one sense, astronomers have reached out with their instruments and brought the planets visually nearer home. Their distances have been measured; the laws governing their real and apparent motions have been learned; knowledge of their physical states has been acquired. As one sees Venus glowing above the horizon as a brilliant evening star, it is possible to picture something of what it must be like on that distant body. And so it is with Jupiter, Saturn, and Mars — we can compare them with each other and with the earth. It is almost as though one were embarking on an imaginery journey into interplanetary space, traveling from one planet to another with speed as great as thought.

These four bright planets are shown on the front cover as they appear through the telescope.

One of the first discoveries that the beginner makes is that there is a striking difference between planets and stars. While the stars appear to be in definite constellation patterns, the planets are continually shifting their positions against this background of the sky. The same planets are not with us at the same time each year; they shuttle back and forth in the sky in a manner that at first seems quite erratic and unpredictable. But in time, as one becomes familiar with the planets' motions, he can anticipate their respective appearances among the stars at any time. Each of these neighbor worlds assumes an individuality all its own.

Toward the end of this month Venus will be becoming a conspicuous morning star, farther above the southeastern horizon each morning before sunrise. By Christmas it will be even more striking. At times Venus is nearer to the earth than any other principal planet. When it is between the sun and the earth, it is only 26 million miles away, about 10 million miles closer than we ever come to Mars. But despite this and the fact that Venus is the brightest planet, no one has ever actually viewed the planet itself. This paradox exists because Venus is shrouded in a dense layer of atmosphere.

Certainly this would be a poor location for an astronomical observatory, for it is a world on which every day is cloudy and where there is probably never a star visible in the night sky. But we need not worry about it, for it is improbable that life exists on the planet. Although quite similar to the earth in size (its diameter is about 7,700 miles), Venus has an atmosphere apparently composed very largely of carbon dioxide, and there is little if any oxygen or water vapor. This is the condition that prevails in the upper levels of the atmosphere. Since we cannot penetrate its lower levels, we do not definitely know what it is like there.

Venus requires about 225 days to complete one revolution about the sun. Its period of rotation has not been determined, but appears to be rather long, perhaps about as long as that of our moon.

There are just two planets whose orbits lie between the earth and the sun. These are Mercury and Venus, and for this reason these two planets are never observed at great distances from the sun in the sky. Venus' maximum elongation from the sun is 48 degrees; Mercury's is 28 degrees. Therefore, except in high latitudes, these planets are not observed late at night.

Mercury is just about as different from Venus as can be imagined. It is only about 3,100 miles in diameter. It makes a complete revolution of the sun every 88 days, so that its year is a little shorter than three months on the earth. And whereas Venus is so "cloudy" we have never had a look at its surface, Mercury is practically without atmosphere — a condition very similar to that which prevails on the moon. Because of its proximity to the sun, temperatures on the daytime side of Mercury are high enough to melt lead, while on the dark side it is very cold. And what is more, the planet turns on its axis in the same time that it requires to revolve around the sun. This means that Mercury always keeps the same face toward the sun. On one side of Mercury is perpetual day, and on the other, perpetual night.

Although at present it is too near the sun to be observed, Mars, most talked-about planet besides the earth, will be making its debut in the morning skies of early 1947. This planet is distinguished by its ruddy hue — perhaps this is the reason it was named for the god of war. Revolving around the sun in 687 days, Mars has a year a little short of two of ours. Approximately every two years and two months, this planet is on the opposite side of the earth from the sun and in the most favorable position for observation. It was so situated in early January of this year and will be again in February of 1948. At oppositions when it is nearest the earth, Mars' distance is about 34,500,000 miles. At less favorable oppositions, it may be separated from the earth by a distance of nearly 63 million miles.

By observing the time required for certain conspicuous markings to return to the same relative positions, astronomers have determined the period of rotation for Mars as 24 hours, 37 minutes, 23 seconds — a Martian day is almost the same length as a day on the earth. The axis of Mars is tilted to the perpendicular to the plane of its orbit about as much as the earth's axis is tilted, 23½ degrees. The north star for Mars is Deneb, the bright star in the constellation of Cygnus, the Swan.

Conspicuous white caps have been observed and photographed around the north and south poles of Mars. These polar caps change with the Martian seasons. A polar cap turned away from the sun increases in size while the op-

AMERICAN ASTRONOMICAL SOCIETY ELECTS OFFICERS

Dr. Otto Struve, director of Yerkes and McDonald observatories, was elected president of the American Astronomical Society at its 75th meeting at Madison, Wis., in September. He succeeds Dr. Harlow Shapley, director of Harvard College Observatory, who has served the expiring three-year term. Dr. Donald H. Menzel, of Harvard, was elected to succeed Dr. J. A. Pearce, of Victoria, as vice-president.

After a long period as secretary of the society, Dr. Dean B. McLaughlin, of the University of Michigan Observatory, resigned in favor of Dr. C. M. Huffer, of Washburn Observatory of the University of Wisconsin. A similar change was made in the office of treasurer, with Dr. J. J. Nassau, of Warner and Swasey Observatory, succeeding Dr. Keivin Burns, of Allegheny Observatory.

THE METEORITICAL SOCIETY

The new name of the Society for Research on Meteorites is the Meteoritical Society. Its ninth meeting was held at Arizona State College, Flagstaff, and at Meteor Crater on September 9th and 10th. The following officers were elected for the 1946-1950 term: *president,* Dr. Arthur S. King, Mount Wilson Observatory; *vice-presidents,* Dr. F. R. Moulton, American Association for the Advancement of Science; Dr. C. P. Olivier, Flower Observatory; Dr. L. J. Spencer, London, England; *secretary,* Oscar E. Monnig, Texas Observers; *treasurer,* L. F. Brady, Museum of Northern Arizona; *editor,* Dr. Frederick C. Leonard, University of California, Los Angeles.

...ET TO ANOTHER

...R. C..., *Hayden Planetarium*

posite cap diminishes; half a Martian year later the situation is reversed in the two hemispheres. Color changes in other regions of the planet have also been observed to follow seasonal rhythm closely.

In addition to the polar caps, other markings, including various indistinct geometrical patterns and lines of somewhat doubtful existence, have from time to time been reported by various observers. The most startling of these were the *canali,* described by the Italian astronomer, Schiaparelli, in 1877. As popularly interpreted in America, these "canals" of Mars set off a tempest of speculation and some people even went so far as to presume that they were the work of intelligent beings — a system of waterways constructed to carry water from the polar regions to the more arid regions near the Martian equator. Much of this popular interest resulted from the inspired writings of Percival Lowell, whose work is still carried on in the Lowell Observatory at Flagstaff, Ariz.

At first the majority of competent astronomers found it quite difficult, if not impossible, to see the mysterious lines that Schiaparelli and Lowell had described. Some even doubted their existence. Later studies, however, have proven that they do exist, although the descriptions and interpretation that Lowell advanced have not been so generally accepted.

Studies of temperature and climate on Mars have provided information that the Martian atmosphere must be far less dense than the earth's. Clouds have been photographed above the surface of the planet, but their nature is not determined. They may be dust clouds in some cases, for water vapor is relatively scarce on Mars. Oxygen is also lacking in sufficient quantity to support life as we know it on the earth. Temperatures on Mars are generally lower than on the earth, because of the planet's greater distance from the sun.

Mars has two small satellites that can be seen only through a powerful telescope. The ruddy planet requires many more years of patient study before some of the questions concerning it can be satisfactorily answered.

To the casual observer, two other planets are frequently conspicuous in the night sky. These are Jupiter, the largest of all, and Saturn, the only planet that can boast of a system of rings. Whereas Jupiter is now near the sun, Saturn is easily seen, rising about midnight and visible in the sky until dawn.

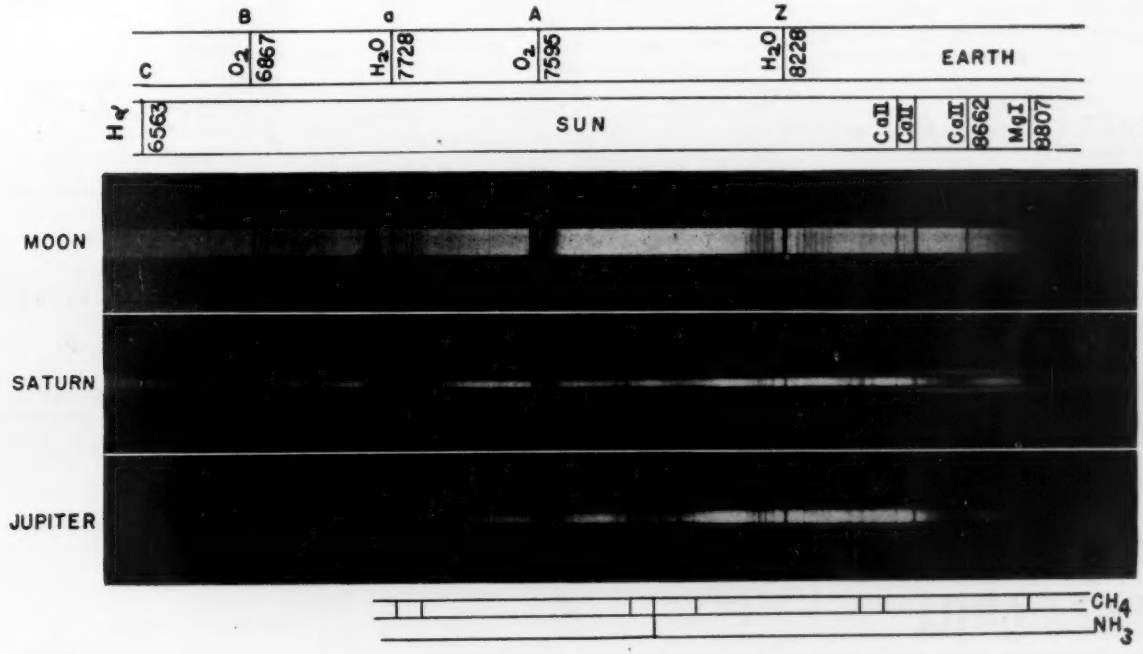
Mercury, Venus, and Mars are sometimes referred to as terrestrial planets because they are in many ways similar to the earth. Jupiter and Saturn are classified as giant planets, the former having a mean diameter of 86,850 miles. Saturn, not counting its rings, is on the average 71,600 miles in diameter. The extreme size of Jupiter is perhaps better appreciated by considering that its volume is 1,318 times that of the earth and its mass is greater than that of all the other planets combined.

At a mean distance from the sun of about 484 million miles, Jupiter requires less than 12 years to revolve once in its orbit, although it rotates on its axis in just under 10 hours. Saturn's distance from the sun is about 887 million miles, and its period some 29½ years. It takes about 20 minutes longer than Jupiter to rotate on its axis.

Through telescopes, dark bands running parallel to their equators and other variable markings have been observed on both Jupiter and Saturn. Most conspicuous on Jupiter, the markings are apparently in the heavy atmospheres of these planets. Large amounts of ammonia and methane have been spectroscopically observed. Jupiter's visible surface has a temperature of about 140 degrees below zero centigrade, and Saturn is even colder.

Jupiter's retinue of 11 satellites and Saturn's nine have provided an interesting field for study and speculation. The four larger moons of Jupiter can be observed with a small telescope or even through a good pair of binoculars. And the rings of Saturn are another favorite object for small instruments.

The three planets so far discovered beyond Saturn are Uranus, Neptune, and Pluto. While Uranus can sometimes be seen by the unaided eye, Neptune is of the 8th magnitude, and Pluto is of photographic magnitude 15.4, quite beyond the range of moderate-sized instruments. At present, it represents the limits of the planetary system.



These infrared spectrograms taken with the 69-inch reflector of Perkins Observatory reveal the compositions of the atmospheres of Jupiter and Saturn. The spectrum of the moon is included in order to show which lines in the planetary spectra originate in the sun and which lines are added by absorption in the earth's atmosphere (telluric lines). Methane is compound CH_4; ammonia is NH_3. Engraving is furnished by the Perkins Observatory, Ohio Wesleyan and Ohio State universities.

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THE ELEMENTS OF ASTRONOMY. New fourth edition

By EDWARD A. FATH, Carleton College. *McGraw-Hill Astronomical Series.* 386 pages, 5¼ x 8¼, 253 illustrations. $3.00.

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METEOROLOGY. With Marine Applications

By WILLIAM L. DONN, Formerly head of Meteorology Section, U. S. Merchant Marine Academy. 465 pages, $4.50.

A general and descriptive text on meteorology and its marine applications. Gives a thorough groundwork in the observation and theory of the weather elements, and then presents an extended treatment of the hurricane, with attention to modern concepts of air masses and fronts as applied to weather interpretation.

STARCRAFT. New second edition

By WILLIAM H. BARTON, JR., late Curator of the Hayden Planetarium, New York, and J. M. JOSEPH, Smedley Junior High School, Chester, Pa. 271 pages, $2.75.

Tells how a practical telescope can be made easily and inexpensively and explains how to use it. In addition, the authors give in simple language a description of everything from meteors to the solar system, and tell how to make star charts and sun dials, how the distances of stars are measured, and how to identify the stars.

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BOOKS AND THE SKY

GEOLOGY APPLIED TO SELENOLOGY

J. E. Spurr. Science Press, Lancaster, Pa., 1945. 430 pages. $5.00.

THE FIRST THIRD of this book appeared earlier, with the subtitle, "The Imbrian Plain Region of the Moon" (reviewed in **Sky and Telescope,** November, 1944), and has now been supplemented by a description of the remainder of the moon's visible surface. For this new material, the same caution must be urged: The book must be read carefully, digested, and then read again. It is a very painstaking analysis of the lunar features, from original approaches.

Mr. Spurr is a geologist from way back and his interest in the moon stems from his receiving at one time a photograph of the Imbrian region, taken at Mount Wilson. Without being full of the discussion of the origin of the lunar craters as it has appeared in astronomical books and magazines, he has looked at this picture (and others he has received since) as the final result of forces similar to those that have worked the earth's surface into the condition we find today. He appreciates the lack of perceivable atmosphere and the long-time absence of water, but he sees no reason why the ordinary igneous processes should be denied.

He discovers the fault lines that run through large regions of the moon's surface; he notes the regions that have been uplifted, others that are sunken. He finds no occasion in the body of the book to mention meteoritic impact, and in a postscript he makes it plain that, while he has thought of it, he has found no reason for introducing this factor as a cause for any lunar features. This is not an astronomical amateur writing, unversed in geology, conversion of energy, and all that sort of thing; this is a geologist, looking at the features of a scene and finding reasonable explanations for their origin.

The author has a breezy way of coining words, to shorten his designations of features and formations: Necfaults are faults found in Mare Nectaris, a grabater is a graben-crater, the result of down-faulting of large areas. Some of the well-established nomenclature is a little abused — maria becomes mares, Mare Serenitatis and Mare Foecunditatis become Mare Serenitas and Mare Fecunditas. But he doesn't do any of this in ignorance, and he warns the reader whenever he is up to such tricks.

The amount of labor in this detailed volume is that which can be expended only by someone in retirement. Small regions of two or three craters have been isolated in many drawings; fault lines have been sketched and other typical features common in geological descriptions are indicated.

The predominating cause for the craters has been, in Spurr's opinion, magma or lava, forced by gas pressure. It raised domes which either broke through the surface as the strength of the lunar surface layers was exceeded, or collapsed as the gas pressure was suddenly or slowly released by escaping through one or more vents. The normal faulting and folding processes known on earth have complicated the results. There have been extensive remeltings of large areas, and inundations by lava. There have been some explosions that have flung ash from craters for distances of hundreds of miles across the moon's surface.

All of these mechanisms have worked on earth; the author sees no reason to apologize for their action on the moon. He does not seize upon one or two features, and cry, "See here? This proves it!" He takes it all very calmly, and by sheer weight of calmness makes his position very strong. As a matter of fact, he avoids opportunities to demonstrate stages of development of craters. For example, he does not mention the domes near Arago and near Hortensius and Milichius — domes which didn't quite become craters. He does not play upon the many domes in the floors of large craters, where resurgences of activity almost made craters centered inside craters. He plays down Wargentin and the similar objects which appear to be craters filled to the brim. I must confess that the domes and the Wargentin-like objects (and the long strings of craterlets) appeal to me as the best evidences that Spurr's story is, for the most part, close to the truth.

Maybe, before the century is out, exploration of the moon will decide defi-

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THE BOOK CORNER

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nitely for or against meteoritic impact as a principal cause for the lunar features. But anyone who believes it now must read this book, to see how at least one geologist feels about it. The only way to convince some of us to neglect such material as his is to have a new crater formed on the moon, by meteoritic impact. That would be news!

ROY K. MARSHALL
Fels Planetarium

PHOTOMETRIC ATLAS OF STELLAR SPECTRA

W. A. Hiltner and **Robley C. Williams.** University of Michigan Press, Ann Arbor, 1946. Unpaged. $7.50.

JUST AS THE advent of spectroscopy added a new dimension to the study of stars, the applications of the microphotometer have added a new dimension to stellar spectroscopy. The older school of spectrum analysis and classification pictured the spectrum in terms of its photographic appearance. For several decades we have realized the necessity of thinking of the spectrum as a whole, and of the lines crossing it, in terms of energy distribution. A picture of the spectrum as an energy diagram is a natural sequel to this development; the trend of astrophysical spectroscopy has been in this direction, and will continue so as regions outside the readily photographed range of wave lengths are explored.

A notable advance in the conversion of photographed spectra into energy diagrams has been made in the direct-intensity microphotometer, developed at Michigan by Williams and Hiltner. This machine makes possible the rapid and accurate conversion of photographed spectra into energy diagrams.

The **Photometric Atlas** contains the first extensive publication of such diagrams for stellar spectra, made from Coudé spectra of the McDonald Observatory. It is an epoch-making work, and one to kindle the enthusiasm of anyone who works with spectra.

Eight spectra are reproduced, between wave lengths about 3900 and 6700. Each star is conveniently arranged in a booklet, the energy diagrams being direct reproductions, reduced to half size, of the microphotometer tracings. The stars represented are Beta Orionis (**B8** Ia), Alpha Lyrae (**A**oV), Alpha Canis Majoris (**A**IV), Alpha Cygni (**A2** Ia), Alpha Canis Minoris (**F5**IV), Alpha Persei (**F5** Ib), Alpha Bootis (**K2** pec) and Alpha Orionis (M2 Ib). While representative and well chosen, these eight stars cannot cover the spectral sequence, and they whet the appetite of the student of astrophysics.

The **Atlas** is a milestone in the study of stellar spectra, and a symptom and forerunner of new trends in astrophysics. It will be indispensable to astronomers; and can be greeted with enthusiastic praise. We hope it is the first of many such publications.

CECILIA PAYNE-GAPOSCHKIN
Harvard College Observatory

ASTRONOMICAL ANECDOTES

(Continued from page 9)

Of all this great establishment. But this
Was not enough; in less than ten years more
Another structure came to be, to care
For students who had filled Uraniborg
To overflow. The Castle of the Stars —
He called it Stjerneborg — was built to house
Great instruments below the ground, to sweep
The skies whenever skies were clear. No crown
In all the world had dealt more lavishly
With any watcher of the skies than had
King Frederick.

As visitors to Hveen
There came the great of many lands: King James
Of Scotland — he who sat on England's throne
In later days as James the First — he came
To walk the garden through and to exclaim
His wonder at the fittings of this place —
This citadel from which to launch forays
To conquer heav'n itself, to make it yield
Its treasures of the secrets of the spheres.
The royal tribe of Denmark looked upon
This isle of Hveen almost as summer home,
And even when in spring the skai blew cold
From northwest out of icy seas, or king
Or consort or some royal child might be
Discerned atop some lofty tow'r, awatch
To see the ships that plied the waters round
About the isle of Hveen.

At night when skies
Were clear, and stars bestrewed all heaven's span,
The master of this place, Tycho himself,
Might be at work on his own measurements
To capture places of a thousand stars
For marking on the five-foot globe begun
At Augsburg many years before. But when
A novice at the work might ask for aid
And guidance, Tycho Brahe would work with him
To demonstrate the patient care with which
The instruments must be employed to take
The gold from dross of all that wheeled above
Them in the sky.

And when the times of clouds
Should be at hand, the pupils gathered then
About the feet of Tycho, in the room
Where common intercourse was held about
Affairs of stars, but also oft of things
Divorced from stars, of love, and life and lands
Across the face of Europe. Tycho then
Would tell them of his travels and of all
The scholars he had visited when he
Was young as they. And, too, he told how birth
Somewhat had forced him to deny the stars
Until by order of his king he'd built
Uraniborg and Stjerneborg, and took
His noble duties and his stars at once;
For he was master of an isle that seemed
A kingdom all its own. The stars supplied
The motive for their gathering on Hveen,
And were, indeed, almost the very gods
Whose shrines they worshipped at. So rev'rent were
The pupils Tycho had assembled here
That many aped the master as he worked
Always in finest robes, for only cloth
Of noblest weave, and colors rich, could serve
As garments fitting for the ones who sought
To touch the throne of all eternity.

(Concluded next month)

R. K. M.

NEW BOOKS RECEIVED

ATOMIC ENERGY IN COSMIC AND HUMAN LIFE, *G. Gamow*, 1946, *Macmillan*. 161 pages. $3.00.

The author of *Mr. Tompkins in Wonderland* discusses modern nuclear physics, how the stars use atomic energy, and how man can use atomic energy. The foreword is by Henry Norris Russell.

Planetarium Notes

ADLER PLANETARIUM

900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.

STAFF: *Director,* Wagner Schlesinger. *Other lecturer:* Harry S. Everett.

November: THE MOON AND ECLIPSES. The nature of the moon and conditions existing on its surface are discussed. The motion of the moon and the causes of eclipses are demonstrated.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers:* Nicholas E. Wagman, J. Frederick Kunze.

November: POETRY OF THE STARS. Interpreting poetic allusions to the heavens from ancient times on—under the stars. ECLIPSES—PAST AND FUTURE. Presenting the mechanism and significance of eclipses, with a "preview" of the November 23rd eclipse.

December: STAR OF BETHLEHEM.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Rittenhouse 3050

SCHEDULE: 3 and 8:30 p.m. daily; also 4 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

November: THROUGH GREAT TELESCOPES. A survey of the universe, from the earth and moon to the farthest bounds explored today. The relations between various types of objects will be explained.

December: STAR OF BETHLEHEM.

GRIFFITH PLANETARIUM

P. O. Box 9866, Los Feliz Station, Los Angeles 27, Cal., Olympia 1191

SCHEDULE: Friday and Saturday, 3 and 8:30 p.m.; Sunday at 3, 4:15, and 8:30 p.m.

STAFF: *Director,* Dinsmore Alter. *Other lecturers:* C. H. Cleminshaw, George W. Bunton.

November: THE MOON. Description and telescopic pictures of the moon's surface, its motions and phases, times of rising, the tides, eclipses, will be shown and discussed.

December: OUR STAR, THE SUN.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Robert R. Coles, Catharine E. Barry, Shirley I. Gale, Edward H. Preston.

November: FROM ONE PLANET TO ANOTHER. The universe we observe depends upon our point of perspective. How does it look from Mars, Saturn, or Venus? In November we discuss this interesting topic in the planetarium.

December: THE WISE MEN'S STAR.

OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

A Partial Eclipse of the Sun

OF FOUR PARTIAL ECLIPSES of the sun this year, that of November 23rd is the only one seen from the United States. Very little of spectacular interest can be seen in a partial eclipse, but the progressive notching of the sun's disk by the moon can be observed. Watch for first contact on the northwest limb and last contact in the eastern section. The last contact will be easier to time, as you may watch the moon gradually slide off — on first contact you cannot see the moon until it has encroached upon the sun.

There may be a number of sunspots, for maximum is approaching, and the moon may be seen in contact with some spots. With a good telescope, some mountains on the south rim of the moon may be seen.

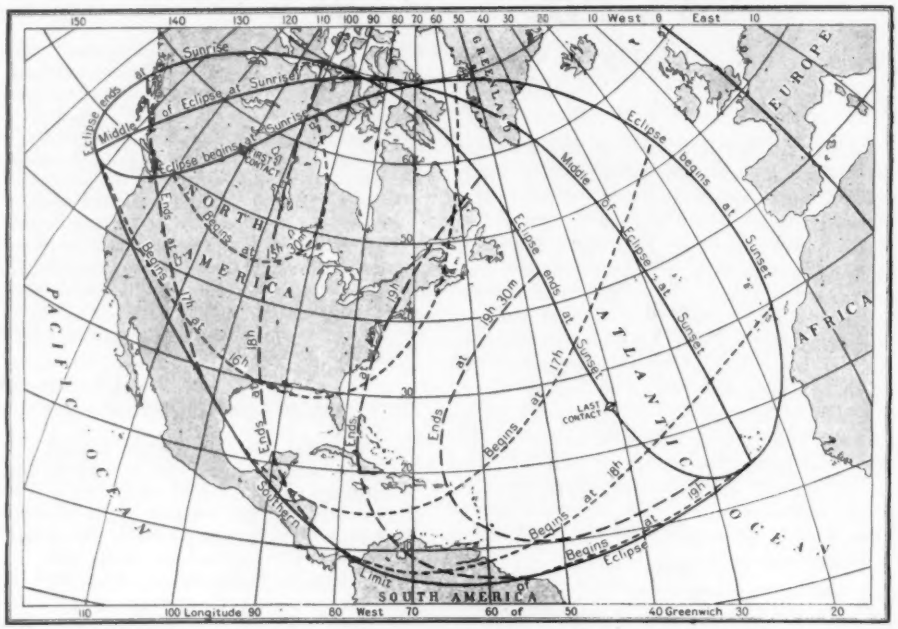
A word of caution: At no time look directly at the sun, and especially do not use an optical instrument unless it is properly shielded. Smoked glass or dense photo negatives will be sufficient for the naked eye, and the object lenses of binoculars can be similarly protected. With a telescope the image should be projected on white paper, unless you have a specially designed solar prism for direct observations. Several dense filters and crossed polaroids may also be employed.

The sun will be 77.6 per cent obscured at maximum in southern Greenland, and the eclipse can be seen in all of Canada and in the United States except most of California and Arizona. Mid-eclipse occurs in the western states in the morning of November 23rd, and shortly after noon in the East. Approximate times of the beginning and ending of the eclipse for your location can be obtained from the accompanying chart. The magnitude of obscuration at various cities is here given:

Atlanta, Ga., 0.36; Augusta, Me., 0.63; Austin, Tex., and Boise, Ida., 0.11; Cambridge, Mass., 0.60; Cleveland, O., 0.50; Denver, Colo., 0.18; Madison, Wis., 0.43; New Haven, Conn., 0.58; New Orleans, La., 0.22; New York, N. Y., 0.56; Pittsburgh, Pa., 0.50; Portland, Ore., 0.08; Santa Fe, N. M., 0.08; St. Louis, Mo., 0.36; Washington, D. C., 0.51.

EDWARD ORAVEC

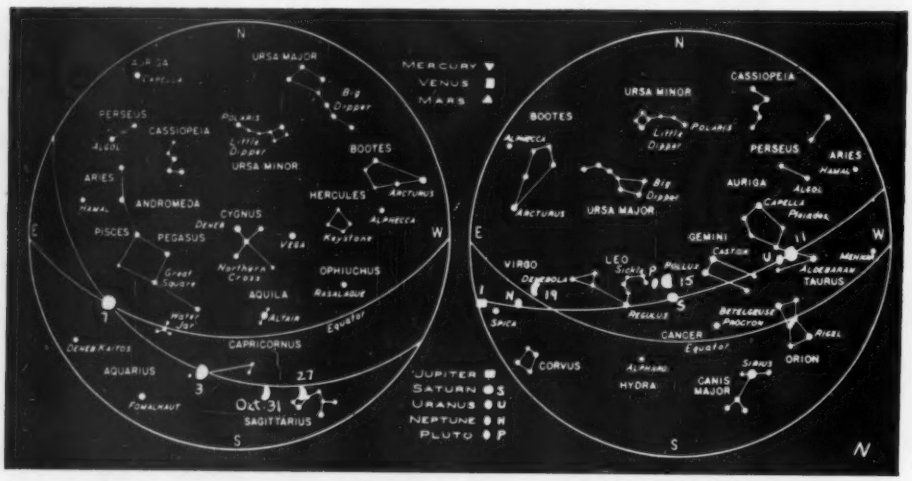
PARTIAL ECLIPSE OF NOVEMBER 23, 1946



Note - *The hours of beginning and ending are expressed in Universal Time or Greenwich Civil Time.*

Reproduced from "The American Ephemeris and Nautical Almanac."

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 5:30 a.m. local time on the 7th of the month, and at 4:30 a.m. on the 23rd. At the left is the sky for 5:30 p.m. on the 7th and 4:30 p.m. on the 23rd. The moon is shown for certain dates by symbols which give roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury will not be visible most of November, but during the first few days look for it half an hour after sunset low in the southwest sky. Mercury passes inferior conjunction on the 21st.

Venus reaches inferior conjunction on the 17th, moving into the morning sky. In the first few days of November the planet can be seen about half an hour after sunset. Again toward the end of the month, Venus can be seen, but in the morning sky. By the 30th it will rise 1½ hours before the sun and will be of magnitude −3.9. With a telescope or good binoculars Venus may be seen at conjunction (19:00 GCT) on the 17th, nearly 4° south of the sun. The planet will appear as an extremely thin crescent, its diameter 63″, and in a good-sized telescope the entire disk may be seen surrounded by a line of light.

Mars cannot be seen this month or for some months to come, as it is traveling close to the sun.

Jupiter rises one hour before the sun on November 15th and two hours before by the 30th, when the planet will be ½° north of Alpha Librae. About this time, Venus and perhaps Mercury can be seen below Jupiter, all three within 8° of each other.

Saturn, in central Cancer, remains almost stationary all month. Eastern quadrature occurs on the 1st, and Saturn begins retrograde motion on the 21st. It rises about five hours after the sun sets. Its brightness has increased slightly, to magnitude 0.4.

Uranus can be found, with optical aid, in western Taurus south of Beta. Its position is $5^h\ 20^m$, $+23°\ 13'$, on the 15th, and it is retrograding as it approaches opposition next month.

Neptune is too near the sun for favorable observation.

E. O.

OCCULTATIONS FOR NOVEMBER

2-3 **37 Capricorni** 5.8, 21:31.8 −20-19.6, 9, +69° −5° Im: **A** 23:23.8 −1.0 +1.8 19°; **B** 23:28.6 ... ... 10°; **C** 23:11.7 −1.3 +2.2 20°; **D** 23:20.3 ... ... 4°; **E** 22:59.5 ... ... 0°; **F** 22:12.4 −1.8 +2.9 30°.

2-3 **143 B Capricorni** 6.2, 21:40.2 −19-52.1, 10, +71° +4° Im: **E** 4:16.5 −2.7 −3 8 126°; **G** 3:27.1 −1.3 0.0 59°; **H** 3:14.3 −2.3 +0.2 76°; **I** 3:15.0 −1.3 +0.5 50°.

4-5 **33 Piscium** 4.7, 0:02.6 −6-00.6, 11, +84° +3° Im: **A** 22:32.4 −0.8 +2.1 38°; **B** 22:37.7 −0.7 +2.1 33°; **C** 22:21.2 −0.7 +2.1 40°; **D** 22:29.8 −0.6 +2.2 32°; **E** 22:15.6 −0.4 +2.2 34°; **F** 21:53.3 −0.2 +1.7 54°.

5-6 **24 B Ceti** 6.0, 0:07.5 −5-32.9, 12, +85° +11° Im: **A** 1:43.6 −3.0 −0.7 108°; **B** 1:39.7 −2.3 0.0 97°; **C** 1:31.4 −3.0 −0.3 106°; **D** 1:26.3 −2.1 +0.5 90°; **E** 1:01.4 −1.6 +1.2 79°; **F** 0:37.9 −1.7 +1.0 89°; **G** 0:55.4 −0.6 +1.9 48°; **H** 0:24.4 −0.5 +1.7 65°.

6-7 **26 Ceti** 6.2, 1:01.0 +1-04.7, 13, +88° −6° Im: **A** 3:14.4 −1.8 +0.3 75°; **B** 3:13.8 −1.5 +0.6 66°; **C** 3:03.9 −2.0 +0.5 76°; **D** 3:03.5 −1.5 +0.9 61°; **E** 2:42.2 −1.3 +1.6 49°; **F** 2:15.8 −1.4 +1.7 57°; **G** 2:52.0 +0.2 −2.8 355°; **H** 2:10.9 −0.3 +2.6 16°.

6-7 **33 Ceti** 6.2, 1:07.8 +2-09.5, 13, +65° −21° Im: **B** 7:25.9 −0.5 −0.5 64°; **C** 7:29.2 −0.8 −1.1 86°; **D** 7:23.5 −0.7 −0.6 68°; **E** 7:14.9 −1.1 −0.4 71°; **F** 7:12.6 −2.2 −1.6 101°; **G** 7:02.5 −0.3 +2.2 7°; **H** 6:32.7 −1.4 +1.4 42°; **I** 6:58.3 ... ... 353°.

12-13 **52 Geminorum** 6.0, 7:11.4 +24-58.8, 19, +71° +6° Em: **A** 7:45.4 −1.8 +1.7 241°; **B** 7:47.7 −1.6 +1.1 252°; **C** 7:29.6 −1.6 +2.8 226°; **D** 7:35.8 −1.5 +1.6 247°; **E** 7:13.7 −1.1 +2.0 242°; **F** 6:41.6 0.0 +3.6 210°; **G** 7:05.1 −0.8 +0.7 297°; **H** 6:46.8 −0.3 +1.2 264°; **I** 6:57.4 −0.7 +0.5 304°.

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, GCT, **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**E** +91°.0, +40°.0
B +73°.6, +45°.6	**F** +98°.0, +30°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0
I +123°.1 +49°.5	

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

For additional occultations consult the **American Ephemeris and Nautical Almanac** and the **British Nautical Almanac**, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

VARIABLE STAR MAXIMA

These predictions of variable star maxima are made by Leon Campbell, recorder of the A.A.V.S.O., Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

November 2, T Centauri, 6.1, 133**63**3; 10, X Ophiuchi, 6.9, 183308; 13, S Herculis, 7.6, 164715; 26, Omicron Ceti (Mira), 3.7, 021**403**; 27, R Trianguli, 6.3, 023133; 27, R Horologii, 6.0, 025**05**0. December 7, S Gruis, 7.8, 221**948**.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

PHASES OF THE MOON

First quarter	November	2, 4:40
Full moon	November	9, 7:10
Last quarter	November	15, 22:35
New moon	November	23, 17:24
First quarter	December	1, 21:47

MINIMA OF ALGOL

November 1, 10:33; 4, 7:22; 7, 4:10; 10, 0:59; 12, 21:48; 15, 18:37; 18, 15:26; 21, 12:15; 24, 9:04; 27, 5:53; 30, 2:42.

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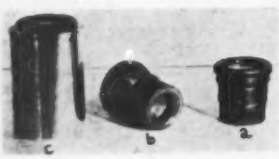

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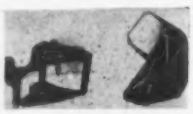

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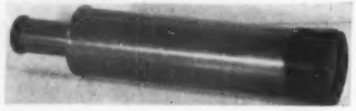

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Further Remarks on the Cassegrainian

The "Spherical" Cassegrainian. A modified type of Cassegrainian was announced by Allen Kirkham, in **Scientific American,** June, 1938. Its principle is that of providing a spherical secondary mirror and correcting for its spherical aberration by undercorrecting the primary mirror by a proportionate amount. It is, of course, much simpler to construct than the conventional type, and many users praise it as being equal in performance. (See **Sky and Telescope**, January, 1946, page 18.)

All the computations given in this department in August for the conventional Cass apply to this type, the only difference being that the secondary is made spherical (a simple task). The percentage correction for the primary mirror is given by Kirkham as:

$$\text{Percentage correction} = 100\,(1 - \mathbf{e}), \quad (1)$$

where $$\mathbf{e} = -8\,\mathbf{F}_1\,\mathbf{S}/\mathbf{r}^2. \quad (2)$$

In this formula, **S** is the spherical aberration of the secondary, computed by the equation:

$$\mathbf{S} = -\frac{(\mathbf{r}_2 + \mathbf{X})^2}{(\mathbf{r}_2 + 2\mathbf{X})^2}\,\frac{\mathbf{r}'^2}{\mathbf{r}_2}, \quad (3)$$

and **r** is the radius of the marginal zone on the primary mirror. **r'** in equation (3) is the radius of the marginal zone on the secondary. $\mathbf{r}_2$ is the radius of curvature of the secondary mirror, and **X** is equal to **d** plus **p**, as defined in August.

In this form of telescope it is unnecessary to use an elaborate testing setup. The primary may be tested at center of curvature by the usual Foucault test, and its degree of correction determined in the customary way by application of the $\mathbf{r}^2/\mathbf{R}$ formula (see **Amateur Telescope Making,** article by W. Everest). The secondary may be tested for sphericity by interference against its own tool, the latter being polished and tested with the Foucault test.

George P. Arnold, in the August, 1946, **Scientific American,** submits a simplification of Kirkham's formulas wherein he combines equations (1), (2), and (3) into one equation:

$$\mathbf{N} = 1 - \frac{4\mathbf{Y}^2\,(\mathbf{X} + \mathbf{Y})^2}{\mathbf{r}_1\,\mathbf{r}_2\,\mathbf{X}^2}, \quad (1a)$$

where **N** is the percentage correction, $\mathbf{r}_1$ and $\mathbf{r}_2$ are the radii of curvature of primary and secondary. **Y** is equal to $\mathbf{F}_1 - \mathbf{d}$, as defined in August.

Correction. Since preparation of the article in August, Allyn J. Thompson has pointed out that the equation given then for the diameter of the secondary, although in accordance with other presentations of the subject, does not conform to the value obtained by preparing a scale drawing of the proposed instrument. Investigation of the reason for this discrepancy discloses that we, along with others, have been guilty of a false concept.

It has often been said that the final image of the Cassegrainian is formed **as if** the rays came from a mirror equal in size to the primary and located at a distance equal to the equivalent focal length of the telescope. This sounds quite reasonable, and is confirmed by tracing rays to the axial image point, but it is a misleading statement when applied to an extra-axial image point. The correct statement of the case is something like this:

For each image point, there is an "equivalent" mirror, equal in size to the primary and located at a distance equal to the equivalent focal length of the telescope, but these "equivalent" mirrors are not in the same location for different image points. The center of the "equiva-

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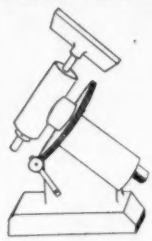

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lent" mirror for a given image point may be found by extending a line passing through the image point in question and through the center of the secondary mirror.

Hence, it may be said that, in the case of a Cassegrainian with a 10-inch primary, of focal length 30 inches and an equivalent focal length of 150 inches, the "equivalent" mirror is 50 inches in diameter at a distance of 150 inches from the final focal plane. Each image point, however, is formed from a cone of rays whose base is 10 inches in diameter, and the bases of these cones of rays are distributed over the 50-inch "equivalent" mirror in exactly the same way as the image points are distributed in the image plane. All these cones of rays intersect in the common cross section represented by the secondary mirror.

When the telescope is perceived in this way, it is evident that the diameter (**a**) of the secondary mirror, when computed by equation (3) in the August article, is too large. As the secondary mirror must also be a cross section of the complete cone of rays from the primary mirror, we must make the calculation as follows:

The linear diameter of the final field of view is **b** (a value adopted from the size of the largest eyepiece or of the photographic plate). The **amplification** is **M**, equal to $\mathbf{F'/F_1}$. Therefore,

$$\mathbf{b'} = \mathbf{b/M}, \qquad (4)$$

where **b'** is the linear diameter of the field of view of the primary mirror. We use this value, and the primary focal length, $\mathbf{F_1}$, and compute the secondary diameter exactly as we would for a Newtonian telescope:

$$\mathbf{a} = \frac{(\mathbf{F_1} - \mathbf{d})\,(\mathbf{A} - \mathbf{b'})}{\mathbf{F_1}} + \mathbf{b'}. \qquad (5)$$

The difference between this and formula (3) in August is small, but not insignificant.

This discrepancy is disclosed by a scale drawing. We remind the reader that a scale drawing is an almost indispensable means of checking optical calculations, and such a drawing should always be prepared.

E. B. B.

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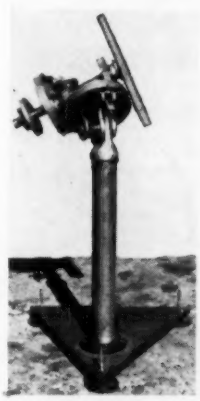

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GIACOBINID METEORS ARRIVE ON TIME

(Continued from page 5)

—10, for it lighted the house above the moonlight."

On Tuesday evening, a party from Harvard went aloft for 6½ hours in a Coast Guard PBM seaplane based on the Coast Guard air station at Salem, Mass., Lt. Comdr. R. W. Blouin as pilot. After cruising over the Boston area and Massachusetts Bay for several hours, the plane flew north to Portland and east nearly to Nova Scotia. Northern lights were seen much more frequently than meteors, but the trip on Tuesday demonstrated the ability of the plane to outrun the clouds if not to fly over them.

The flight Wednesday evening was made in a PBY amphibian, Lt. Comdr. J. W. Williams, pilot, which took off from Beverly air base about 8:00 p.m. EST. During the 6-hour flight over the Gulf of Maine, courses were set to remain in partially clear areas, but the curve of meteor frequencies clearly shows several periods under high clouds. The average altitude maintained was 10,000 feet. The PBY has twin blisters which enable four or five observers to work together with one or two recorders.

For about three hours beginning at 8:40 EST, an average of three observers plotted 141 meteors and counted about 560 more. The limiting magnitude was at no time fainter than 3, and as many meteors of zero magnitude and brighter were recorded as of fainter magnitudes. The meteor rates increased from five or six per minute at 10:20 to 17 per minute at 10:50, which was the time estimated as maximum by the observers in the plane. In the minute at 10:51, 23 meteors were observed, including three brighter than Sirius, eight brighter than Vega, eight as bright as Altair.

Participating in both flights were Mrs. Margaret W. Mayall and the editors of **Sky and Telescope.** On the first flight Carl Shapley and members of the **Sky and Telescope** staff also took part; on the second flight Father R. LeClaire, M. Savedoff, Alan Shapley, all of Harvard, and Dr. Royal M. Frye, of Boston University, completed the observing and recording personnel.

The arrangements with the Coast Guard were made between Lawrence Dame, of the Harvard University News Office, and Comdr. John F. Harding, U. S. Coast Guard Search and Rescue.

METEOR SHOWERS

The Leonid shower remains somewhat active in mid-November; rates between 15 and 20 per hour at maximum may be expected. The shower may be seen from the 12th to the 17th, with maximum about the 15th. A quarter moon is close to the radiant, both rising near midnight, and observations must be made in the morning hours. Very swift meteors will be seen to emanate from the region of Gamma Leonis.

The Andromedids may show a few meteors between the 25th and 30th. They are typically very slow. The radiant is close to Gamma Andromedae. E. O.

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709-Y	Amber	5-7/8"	1.00

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3006-Y	Porro Abbe Prism	$0.25 each
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3021-Y	Amici Roof Prism (3rd Grade)	.25 each
523-Y	Six Threaded Metal Reticle Cells	.25
624-Y	Neutral Ray Filter size 4¾" x 2½"	.25
3022-Y	Round Wedge 65 mm. diam. ..	5.00 each
16-Y	Level Vial, 48 mm. long	.20 each
1040-Y	6 Power Magnifier—diam. 25 mm.	.25 each
2036-Y	Standard Crossline Reticle — diam. 29 mm.	.50 each
1034-Y	Burning Glass Lens	.25 each
535-Y	Small First Surface Mirror ..	.30
3003-Y	Amici Roof Prism with Corrected Roof	2.50
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6162-Y	25	122	1.25
6164-Y*	26	104	.80
6168-Y	29	76	1.25
6171-Y	32	171	1.00
6173-Y*	34	65	1.00
6176-Y*	38	131	1.00
6177-Y*	39	63	1.10
6178-Y*	45	189	1.50
6179-Y*	46	78	1.25
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3006-Y	Porro-Abbe	9 mms.	9 mms.	.25
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3029-Y	Dove	16 mms.	65 mms.	1.25
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HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for transplanted amateurs who may wish to visit other groups. The asterisks denote societies whose members receive *Sky and Telescope* as a privilege of membership.

City	*Organization*	*Date*	*P.M.*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	*BOND AST. CLUB	1st Thu.	8:15	Oct.-June	Harvard Obs.	Miriam Dickey, Harvard Observatory
"	*A.T.M.s OF BOSTON	2nd Thu.	8:00	Sept.-June	Harvard Obs.	A. G. Hall, 206 Maplewood St., Watertown
BROOKLYN, N.Y.	AST. DEPT., B'KLYN INST.	Rd. Table 3rd Thu.	8:15	Oct.-April	Brooklyn Inst.	William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473
BUFFALO	A.T.M.s & OBSERVERS	.....	.....	Oct.-June	Mus. of Science	J. P. Dow, E. Main St., R. D. 3, E. Aurora
CHATTANOOGA	BARNARD A. S.	4th Fri.	7:30	All year	Chattanooga Obs.	C. T. Jones, 302 James Bldg., *CHat.* 7-1936
CHICAGO	*BURNHAM A. S.	2nd Tue.	8:00	Sept.-June	Chi. Acad. of Sciences	J. M. Showalter, 6200 Kenmore Ave.
"	CHICAGO A. S.	Monthly	8:00	.....	Adler Planetarium	Adler Plan., *Wabash* 1428
CINCINNATI	*CIN. A. A.	2nd Fri.	8:00	Sept.-June	Cincinnati Obs.	Dan McCarthy, 1622 DeSales Lane
"	*CIN. A. S.	2nd Wed.	.....	.....	5556 Race View Ave.	A. H. Hasemeier, 2945 Ravogli Ave.
CLEVELAND	CLEVELAND A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Virginia Burger, Warner & Swasey Obs.
COLUMBIA, S. C.	NORTHERN CROSS A.S.	Every Mon.	8:15	All year	Melton Observatory	Dr. L. V. Robinson, Univ. of S. C.
DAYTON	A.T.M.'s OF DAYTON	3rd Sat.	Eve.	.....	Private homes	W. C. Braun, New Lebanon
DAYTONA BEACH	D. B. STARGAZERS	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	*DETROIT A. S.	2nd Sun.	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	*N. W. DETROIT A. S.	1st Tue.	8:00	Sept.-June	Redford High Sch.	John W. Broxholm. 21412 Pickford
DULUTH, MINN.	DULUTH AST. CLUB	Meetings suspended				Ray S. Huey, 1822 E. 3rd St.
FT. WORTH	TEX. OBSERVERS	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	ALA. A. A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
GENEVA, ILL.	*FOX VALLEY A. S.	3rd Tue.	8:00	.....	Geneva City Hall	Wm. Siekman, Woodlawn Ave., Batavia
HOUSTON	*HOUSTON A. S.	Last Fri.	7:30	All year	Mus. Nat. Hist. Annex	W. D. Martin, 5624 Dwinnel Dr.
INDIANAPOLIS	INDIANA A. A.	1st Sun.	2:15	All year	Odeon Hall	E. W. Johnson, 808 Peoples Bank Bldg.
JACKSONVILLE	*J. A. A. C.	1st, 3rd Mon.	8:00	All year	Private homes	E. L. Rowland, Jr., 442 St. James Bldg.
JOLIET, ILL.	JOLIET A. S.	Alt. Tue.	8:00	Oct.-May	Jol. Mus. & Art Gall'y	Mrs. Robert L. Price, 403 Second Ave.
LOS ANGELES	L.A.A.S.	2nd Thu.	8:15	.....	2606 W. 8th St.	A. M. Newton, 2606 W. 8th St.
LOUISVILLE, KY.	L'VILLE A. S.	1st Tue.	8:00	Sept.-May†	University Center, Univ. of Louisville	B. F. Kubaugh, 621 S. 34th St.
MADISON, WIS.	MADISON A. S.	2nd Wed.	8:00	All year	Washburn Obs.	Dr. C. M. Huffer, Washburn Obs.
MEMPHIS	A.T.M.s OF MEM.	Meetings suspended				R. E. Wendt, Jr., 2084 Linden Ave.
MIAMI, FLA.	SOUTHERN CROSS A.S.	Every Fri.	7:30	All year	M. B. Lib. Grounds	A. P. Smith, Jr., 426 S.W. 26th Road
MILWAUKEE	MILW. A. S.	1st Thu.	6:15	Oct.-May††	City Club	E. A. Halbach, 2971 S. 52 St.
MOLINE, ILL.	*POP. AST. CLUB	Wed.†††	7:30	Feb.-Nov.	Sky Ridge Obs.	Carl H. Gamble, Route 1
NEW HAVEN	NEW HAVEN A.A.S.	4th Sat.	8:00	Sept.-June	Yale Obs.	J. J. Neale, 29 Fairmont Ave.
NEW ORLEANS	A.S. OF N. ORLEANS	Last Wed.	8:00	Sept.-May	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
NEW YORK	*A.A.A.	1st, 3rd Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
"	JUNIOR AST. CLUB	1st, 3rd Fri.	8:00	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORFOLK, VA.	*A.A.S. OF NORFOLK	2nd Thu.	8:00	All year	635 W. 29th St.	P. N. Anderson, 635 W. 29th St.
NORWALK, CAL.	EXCELSIOR TEL. CLUB	Thu.	7:00	All year	Excelsior Union H. S.	Geo. F. Joyner, 410 Sproul St.
NORWALK, CONN.	NORWALK AST. SOC.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-5947
OAKLAND, CAL.	*EASTBAY A. A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 6557 Whitney St.
OWENSBORO, KY.	*OWENSBORO A. C.	3rd Sat.	8:00	All year	Public Library	Herman Batt, 1507 Hathaway St.
PHILADELPHIA	A. A. OF F. I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *Rit.* 3050
"	*RITTENHOUSE A. S.	2nd Fri.	8:00	Oct.-May	The Franklin Inst.	A. C. Schock, *Rit.* 3050
PITTSBURGH	*A.A.A. OF P'BURGH	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. Bier, 837 Estella St.
PONTIAC, MICH.	*PONTIAC A.A.A.	2nd Thu.	8:00	All year	Private homes	Harvey E. Orser, 34 Pine St.
PORTLAND, ME.	A.S. OF MAINE	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PORTLAND, ORE.	*AST. STUDY GROUP	1st Wed.	7:00	All year	Central Pub. Lib.	H. J. Carruthers, 427 S. E. 61 Ave.
"	A. T. M. & O.'s	2nd Tue.	8:00	All year	Private homes	N. C. Smale, 831 N. Watts St.
PROVIDENCE, R. I.	SKYSCRAPERS, INC.	Mon. or Wed.	8:00	All year	Ladd Observatory	Ladd Obs., Brown U., *GA.* 1633
RENO, NEV.	A.S. OF NEV.	4th Wed.	8:00	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	ROCH. AST. CLUB	Alt. Fri.	8:00	Oct.-May	Univ. of Rochester	M. L. Groff, 400 University Ave.
SACRAMENTO	SAC. VAL. A. S.	.....	8:00	All year	Sacramento College	S. J. Smyth, 246 41st St.
SAN DIEGO, CAL.	AST. SOC. OF S. D.	1st Fri.	7:30	Oct.-June	504 Elec. Bldg.	R. M. Lippert, Box 41, N. Park Sta.
SCHENECTADY	S'TADY AST. CLUB	Meetings suspended				C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	ST. JOSEPH VAL. AST.	Last Tue.	8:00	All year	928 Oak St.	F. K. Czyzewski, South Bend Tribune
TACOMA, WASH.	TACOMA A.A.	1st Mon.				Dorothy E. Nicholson, 2816 No. Union Ave.
TEANECK, N. J.	BERGEN CO. A. S.	2nd Wed.	8:30	All year	Obs., 107 Cranford Pl.	J. M. Stofan, 332 Herrick
TULSA, OKLA.	TULSA A.S.	Occasional meetings				V. L. Jones, 4-8462
WASHINGTON, D.C.	NAT'L. CAP. AST'MERS	1st Sat.	8:00	Oct.-June	U. S. Nat'l. Museum	L. North, 805 Mt.Vernon Pl. N.W., *Na.* 3377
WICHITA, KANS.	*WICHITA A.S.	1st Wed.	8:00	All year	To be announced	Dollie Ratcliff, 801 Maple, 2-1822
WORCESTER, MASS.	*ALDRICH AST. CLUB	2nd Tue.	7:30	All year	Mus. Natural History	Ruth Foley, 9 Oberlin St., 63101
YAKIMA, WASH.	YAK. AM. AST'MERS	1st Tue.	8:00	All year	Chamb. of Comm. Bldg.	Edward J. Newman, 324 W. Yakima Ave.

†June, Jul., Aug., informal meetings. ††Dinner meeting. †††Nearest 1st-quarter moon.

SKY-GAZERS EXCHANGE

Classified advertisements are accepted for this column at 40 cents a line per insertion, six words to the line. Minimum ad is three lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard Observatory, Cambridge 38, Mass.

FOR SALE: 8" parabolized mirror, unsilvered, in good condition. $40.00. James Bray, 860 Walnut Ave., Burlingame, Cal.

FOR SALE: 1⅞" achromatic refractor by Lumiere, Paris. Collapsible. Terrestrial eyepiece. No tripod. $25.00 plus shipping. Box F, Sky Publishing Corporation, Harvard Observatory, Cambridge 38, Mass.

WANTED: Fine quality refracting telescope with 2½" to 4" objective, finder, equatorial mounting, slow motion, extra eyepieces. Please give full description and price. L. F. Spalding, Box 54, Manchester, Conn.

FOR SALE: 6" parabolic aluminized 26" f.l. mirror of professional make with aluminum cell. Eyepiece in focusing mount 1⅜" f.l. Bought from surplus war lot but have not used. Sell all $50.00. Eugene Zartarian, 560 Audubon Ave., New York 33, N. Y.

WANT TO BUY: Telescope by R. B. Tolles. Anyone having or knowing of such glass, write Dr. F. N. Solsem, Ah-Gwah-Ching, Minn.

WANTED: Blanks of telescopic Pyrex, 20 inches and 16 inches diameter. Box G, Sky and Telescope, Harvard College Observatory, Cambridge 38, Mass.

SPECIAL OPTICAL GLASS. New type Schmidt camera and television mirror blanks, 7" dia. moulded 6" radius concave curve, ribbed back, $2.45 each. 4" dia. moulded blanks, 5" rad. curve, 85c each. 7" dia. ½" thick moulded flat, optical crown correcting plates, $1.65. Write for full information. Nassau Optical Co., Box 602, West Sayville, N. Y.

MAKE OFFER for 10" pyrex mirror, 90" f. l. Figured and aluminized. Easily separates components of Epsilon Lyrae with ⅝" f. l. eyepiece. W. H. Schoenfeld, Jr., 1014 S. 2nd Ave., Maywood, Ill.

FOR TRADE: Smithsonian Contributions to Knowledge, Vol. 34, 1904, containing Draper's and Ritchey's articles on reflectors. Excellent shape. For Splendour of the Heavens, edited by Phillips. Wm. G. Welt, 1019 J St., Modesto, Calif.

DEEP-SKY WONDERS

THIS MONTH the four largest spiral galaxies, which all happen to have about the same right ascension, are inspected with a 6-inch rich-field telescope.

M31, NGC 224, $0^h\ 41^m$, $+41°$, magnitude 5, 160′ x 40′; the great Andromeda nebula and by far the most magnificent in the sky. The telescope, unlike the usual photographs, shows a much brighter nucleus with the extensions quite faint — traces of the dark lanes appear. The two companions are quite faint.

M33, NGC 598, $1^h\ 31^m$, $+30°\ 24'$, magnitude 7.8, 60′ x 40′; much fainter than M31. While no trace of the arms can be seen, it does have a curdled appearance.

NGC 55, $0^h\ 12^m$, $-39°\ 30'$, magnitude 7.8, 25′ x 3′. Most American amateurs have never seen this, but with care it can be caught, about as bright as M33.

NGC 253, $0^h\ 45^m$, $-25°\ 34'$, magnitude 7, 22′ x 6′. The second brightest spiral, pictured on the cover of **Sky and Telescope** for May, 1946, also seems little known to American observers. In the 6-inch it is a bright object.

WALTER SCOTT HOUSTON

STARS FOR NOVEMBER

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

Chart correction: Beta and Gamma Lyrae should be reversed.